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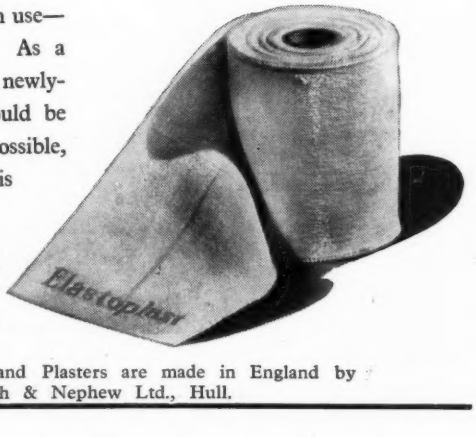

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FOREWORD

No country can compare with England in the organization in detail of methods of preventing disease in industry. What has been done by the Factory Inspectorate of the Ministry of Labour has been well done. But more is needed. Even Medical Inspectors of Factories have had few opportunities of studying conditions from the angle of a works' doctor and these doctors are only a fraction of the demands which industry will make on the profession.

To meet those demands we must turn to the medical schools which are not yet perhaps in possession of all the facts. They will ask what manner of man is needed. We shall not ask every student necessarily to become an expert in occupational diseases, but we may well require him to recognize the response of his patient, in mind and body, to fatigue, to overwork and to monotony. We want him, whenever he sees a patient, to ask what is the cause of his illness. Could it have been prevented and, if so, how? Whether anything in his surroundings at work or at home caused or contributed to his illness. What advice must be given to him or to his family to ward off a recurrence of his illness.

To these questions there can be no really satisfactory answer unless the doctor is familiar both with domestic and working conditions, and it has to be remembered that only a fraction of work in England is done by large firms. The firms that in bulk bear the main burden of the day are generally too small to have a whole-time works' doctor. They will look for help to the general practitioner, and there is nothing in the nature of industrial medicine which is beyond the competence of a sound practitioner. What is the most that we can ask of him in this field? That he possess a higher qualification in medicine and has held a resident appointment at a hospital, that he must have some experience of clinical work and some knowledge of social problems. Then, if he keep up his reading and is a member of a scientific society and knows the grammar of research, we shall be content. In a word, we are asking for a good doctor.

In saying so much I do not deny that special training is required for factory work. An industrial doctor, whether whole time or part time, will neglect his unusual opportunities if he fails to study working conditions. He must learn to control the hazards of industry, he must be versed in the diseases and poisons peculiar to the lives of the men for whose well-being he is responsible; he ought to be skilled in the treatment of accidents. But first and last he must be a good doctor. If he is, all the rest will be given unto him.

He will enjoy singular opportunities of clinical study. James Mackenzie went to St. Andrews that he might keep a small community under unbroken observation for a period of years. The industrial doctor will have such a community under his hand. He will be able to follow the history of the men employed by his firm and at the end he ought to be able to contribute to our knowledge of the natural history of important diseases such as duodenal ulcer. The long-established Medical Branch of the Post Office has shown how this can be done and what may come of it.

But the industrial doctor of the future must have close links with the main chain of general medicine. Academic centres of industrial medicine will arise, as in the new organization at the London Hospital, and the whole-time industrial medical officer of the big firms may probably become in time a specialist and consultant in this field. Thus the structure of industrial medicine will be similar to the general structure of the medical services of the country, working along parallel lines for the good of this important section of the community. It is because of all this that an authoritative scientific journal dealing with these matters is more than welcome. And I have tried to indicate my belief that the *British Journal of Industrial Medicine* should be of the very highest assistance not only to the whole-time industrial doctor but to every doctor whose patients are engaged in industry and who himself may, from time to time, be called upon to advise in local industrial problems.

MORAN.

Royal College of Physicians.

THE EVOLUTION OF AN INDUSTRIAL SOCIETY

BY

MAJOR GREENWOOD

It is always difficult, when thinking of the evolution of a social or economic system, to free ourselves from the tyranny of illusions. No intelligent person now believes in a Golden Age thousands of years ago. It was not polite of Dr. Johnson, when Lord Monboddo—who did believe in a Golden Age—pointing to his ancient house said, ' In such houses, our ancestors lived who were better men than we,' to reply, ' No, no, my lord, we are as strong as they, and a great deal wiser.' But, intellectually, we all agree with the doctor. Emotionally, however, we react differently.

Perhaps, because one of the most beautiful passages in Roman literature is an eulogy of an agricultural labourer's life (Vergil. Georg. II, 458–474); perhaps, because some of us—like the author of the poem—have earned in cities the means of living in the country without being agricultural labourers, we do look back upon England before the ' Industrial Revolution ' with regret. Certainly intelligent men could, without being romantic poets have that feeling at the end of the 18th century. It was not a poet but a statesman who wrote:

> The monks are lazy. Be it so. Suppose them no otherwise employed than by singing in the choir. They are as usefully employed as those who neither sing nor say. As usefully even as those who sing upon the stage. They are as usefully employed as if they worked from dawn to dark in the innumerable servile, degrading, unseemly, unmanly, and often most unwholesome and pestiferous occupations, to which by the social economy so many wretches are inevitably doomed. If it were not generally pernicious to disturb the natural course of things, and to impede, in any degree, the great wheel of circulation which is turned by the strangely directed labour of these unhappy people, I should be infinitely more inclined forcibly to rescue them from their miserable industry, than violently to disturb the tranquil repose of monastic quietude. Humanity, and perhaps policy, might better justify me in the one than in the other !

Those lines were written in 1790, more than 40 years before any State-paid factory inspectors were appointed to report how children were used in factories. The first limitation, by enactment, of the hours of labour of adults came more than a century after Burke's death. That much happened to justify the language quoted, the most superficial reader of our economic history knows. Whether the ' poor ' were happier, more free from disease, more sturdy, better fed in the first than in the last quarter of the 18th century is not a question so easily answered affirmatively as poets suggest. The death rate of a country is not an infallible test; it is, however, *a* test. By that criterion, England was healthier at the end than the beginning of the 18th century and indeed continued throughout the *Sturm und Drang* of the struggle for existence against Bonaparte to be healthier than it was ever to be again until a time within the memory of some now living.

At the beginning of the 18th century the gross death rate was between 26 and 29 per 1000 per annum and gradually increased to a figure between 33 and 36 towards the middle of the century. The rates continued about this level until the last decennium, when a decline began.

A minimum was reached between 20 and 24 per 1000. After the peace of 1815 the death rate rose and, throughout the registration period—viz. after 1839—to the decennium 1871–80, was about 22·0 per 1000. Improvement began in 1871–80 and has continued ever since.

Statistically exact comparisons are impossible, because the data for the 18th century are incomplete and the age constitution of the people has changed. But there is no doubt that the figures quoted are of the right order of magnitude ; in particular it is certain that in the last ten years of the 18th century the rate of mortality was improving considerably and that, in spite of set-backs in particular years, the civilian population was healthier during the war of 1793–1815 than before or since (down to 1871–80).

Although ' obvious ' explanations are often false, I think the ' obvious ' explanation, viz. that the working classes were economically better off in the years of war expenditure, is right. But we must remember that 18th- and early 19th-century industry was still the employment of a minority, and there is adequate evidence that, in the highly industrialized North-West, rates of mortality exceeded those of the East and South.

At the end of the 18th century (the census of 1801) 7·6 per cent. of the English population was in Lancashire and 6·3 per cent. in the West Riding of Yorkshire; by 1841 these proportions had increased to 10·5 and 7·3 per cent. We have no adequate data of regional mortality before registration, but in

1841–50 when the general death rate was 23 per 1000, that of Lancashire was 28 per 1000 and of London 25 per 1000.

It is important, too, to realize that the evils of industrialization which first horrified our professional ancestors, were the *indirect* evils, not the factory but the domestic environment of the workers: their squalid, horrible, living quarters. It is only too easy to put on blinkers, to see nothing but the home or nothing but the working place. The evils of long hours of labour, of brutal oppression, of ghastly accidents due to reckless disregard of dangers, are more dramatic than the squalid misery of homes but, in our study, not more important. Perhaps they are less important.

It is probable that before 1870 (the Factory Act of 1867 strengthened and consolidated the powers of a generation of Acts, and inspection had been effective for more than a generation) the evils which had shocked the public conscience in pre-Victorian days were memories. Chadwick's campaign against domestic and communal insanitation had been less successful than that of Sadler and Lord Shaftesbury against the exploitation in factories of 'hands.' The general death rate of England and Wales remained higher than it had been in the *laissez faire* epoch of 1800–15. Had our ancestors wholly neglected the evils of life *in* factories, left young persons without the protection of laws and inspectors, disregarded extra-domestic evils but rehoused the people, I think the rate of mortality would have begun to fall a century sooner.

This is not a sneer at the efforts of men quite as intelligent and humane as any now living. Probably a great majority of them would have agreed with it but urged, quite correctly, that the best should not be made the enemy of the good. Public opinion 150 years ago was ready to react against the exploitation of children in factories; far from ready to admit that the castle, the proverbial home of every Englishman, was often a horrible den and must continue to be a horrible den, failing a revolutionary change in methods of government and in economic dogmas respecting the sanctity of property.

It may seem that, even within its emotionally accessible range, public opinion reacted slowly. Before the end of the 18th century, the evil of child-labour had been denounced by responsible authors; but in 1832 publicists were still at the Royal Commission or Departmental Committee stage.

In 1796 Perceval submitted to the Manchester Board of Health resolutions which deserve the hackneyed adjective classical. The following passage is almost too familiar to be quoted:

> The untimely labour of the night, and the protracted labour of the day, with respect to children, not only tends to diminish future expectations as to the general sum of life and industry by impairing the strength and destroying the vital stamina of the rising generation, but it too often gives encouragement to idleness, extravagance, and profligacy in the parents who, contrary to the order of nature, subsist by the oppression of their offspring.

Yet more than 30 years passed before any effective measures were taken by the central government.

The explanation is, I think, contained in a less frequently quoted passage of the document:

> From the excellent regulations which subsist in several cotton factories, it appears that many of these evils may, in a considerable degree, be obviated; we are therefore warranted by experience, and are assured we shall have the support of the liberal proprietors of these factories, in proposing an application for Parliamentary aid (if other methods appear not likely to effect the purpose), to establish a general system of laws for the wise, humane and equal government of all such works.

It is not praising ourselves too much to say that British public opinion has nearly always been a generation in advance of its legislative expression. Simon and other writers have pointed out how potent was a growing spirit of humanity in moulding practice before legislative coercion. Indeed, systems which, on paper, have simply nothing to recommend them do not always work badly. Any reader of those novels of Marryat which were written for adults—for instance the really horrible account of the sadistic captain flogging a man for pleasure (*Frank Mildmay*, Chap. XVI)—might see in Johnson's remark,

> 'No man will be a sailor who has contrivance enough to get himself into a "jail,"' another instance of the Doctor's luminous common sense. But the fact that we still survive as a nation, or even the general tone of Marryat's writing, show that in a service where there was virtually no control, except public opinion, over beastliness which a Nazi might envy, life was, statistically speaking, endurable, often happy.

The Health and Morals of Apprentices Act (1802) is usually accepted as the commencement of factory legislation, although it was in form simply an extension of the Elizabethan Poor Law. Hours of labour for these children were not to exceed 12 daily, and a duty of visitation was imposed on Justices of the Peace. In 1819 the employable age of children was fixed at 9 years. None under 16 should work more than 12 hours. Night work was forbidden.

In 1825 the working time on Saturdays was reduced to 9 hours. In 1831, the age of limitation was raised to 18 and prohibition of night work extended to all persons aged less than 21.

The Act of 1833 marked a considerable advance; the earlier Acts applied only to cotton mills, this extended legislation to woollen, worsted, hemp, flax, tow, linen and silk factories. Children under 13 must not work more than 9 hours a day or 48 hours in any week, and nobody under 18 but over 13 (now called a young person) might work more than 69 hours a week or be employed at night.

Medical practitioners were to be judges of age and inspectors, appointed and paid by the State, were to supervise the working of the law.

The inspectors found that the provisions respecting age of the Act of 1833 were not effective and themselves appointed certifying surgeons, a proceeding legalised in 1844. The Act of this year first made provision for the fencing of mill-gearing and shafting and, for the first time, women were included with young persons in the limitation of hours. Another innovation was the half-time system for children of, at least, 8 years.

The famous 10 hours Act of 1847, although concerned wholly with hours of employment, is justly thought to mark an epoch. Young persons and women must not be worked more than 10 hours a day or 58 hours a week; the permitted times were between 5.30 a.m. and 8.30 p.m. Indirectly this Act limited the hours of labour of men; although attempts at evasion—for instance by employing relays of protected persons—were made. An Act of 1850 endeavoured to meet this. Hours of work were to be either from 6 a.m. to 6 p.m. or from 7 a.m. to 7 p.m. with an hour and a half for mealtime within these hours; on Saturdays work was to cease on 2 p.m. This gave a normal working week of 60 hours.

The next important date in the history of legislation is 1867. An Act of that year not only extended the connotation of factories but required mechanical means of removing dust evolved in a manufacturing process which might be inhaled to an injurious extent. It is probable that this provision was inspired by the researches of Greenhow carried out at the request of Simon. In the same year workshops, defined as industrial establishments employing less than 50 persons, were subjected to regulation. Finally we have, at the beginning of the 20th century, the Consolidating Factory and Workshops Act of 1901 which, without introducing any fundamentally new principles, simplified and improved administration.

To reach a conclusion as to the precise effect of changes in the conditions of work on the well-being of the employees through the half century ending in 1901 is difficult. We can, of course, compare the death rates in geographical areas, the inhabitants of which are known to have been mostly employed in factory industry, for instance in the textile towns (*vide infra*) through the decennia from 1851–60 to the end of the century. Changes are, however, resultants of several components: (1) Factory conditions, (2) Housing conditions, (3) Personal hygiene and morale.

What seems an obvious statistical short-cut, viz. to use analyses of occupational mortality rates, which were begun by Farr more than seventy years ago, is something of a blind alley. Here are some of the difficulties. There has been a great increase in the number of occupations studied and in the accuracy of their definition. In Farr's pioneer report of 1851, only 11 occupations were chosen. Now the analysis is complete.

The early classification is vague. Take, for example, the classical instance of industrial silicosis, a hazard recognized in the 16th century (metalliferous miners) and well described in the cutlery industry more than a century ago. Improvements, embodied in legislation, have lessened the danger of inhalation of potentially noxious dust. Can we say, statistically, that workers in silicosis trades are better off than seventy years ago? We may be convinced on the basis of general experience that they are, but we cannot make a statistical proof. Farr had a group of tool file and saw makers, dealers (data of 1861 and 1871). Employing the modern method of statement, their comparative mortality figure was 137. But this group, while certainly including many persons exposed to special hazards, also includes many (dealers) not at special risk. If one takes from the 1931 analysis file cutters, filers, cutlery grinders and cutlers, their relative mortality figure is 159. But this set is confined to persons certainly exposed to risk. There is no valid comparison with the figures of sixty years before ; like is not compared with like.

This is not all. An occupational mortality rate may be high, not because of specific hazards but because of its low economic status or because, for geographical reasons, those employed in it are badly housed. It is only in recent times that analysis by economic status has been attempted.

For the first time in 1931, the mortality rates of the wives of occupied men have been analysed giving a valuable index of the economic-domestic factor. Those who come after us will be more fortunate than we; we have to face the position, viz. that judgment on the past depends on uncertain and confused data. That is why different writers reach wholly different general conclusions. A writer's emotional bias affects his choice of evidence. My own bias leads me to stress what I called above personal hygiene and morale.

One evil of child labour stressed by our ancestors was the impossibility of educating wearied children. A great majority of those who took this point were thinking mainly of religious instruction; perhaps they were wiser than clever young men think, but I shall speak only of the literary instruments.

Our statistical predecessors did not go deeply into educational returns. This question, however, did not escape the notice of William Farr, who frequently tabulated and commented upon the information provided by Marriage Registers. A century ago, one-third of the bridegrooms and nearly half the brides signed the Registers by marks (32·6 per cent. of men and 48·9 per cent. of women in 1841–5). In the year 1846, 32·6 per cent. of males who married in England and Wales signed by mark; in the industrial county of Lancashire 38·7 per cent. and, in the agricultural county of Norfolk, 42·6 per cent. For women the three percentages are 48·2, 65·9 and 50·9. In 1871, the figures for men are 19·4, 20·8 and 27·6; for women 26·8, 38·4 and 22·1. At the beginning of this century (1901) the England and Wales percentage for

males is 2·5, for Lancashire 2·4 and for Norfolk 3·3. The three percentages for women are 2·9, 3·8 and 2·1. In the generation 1846–71, the improvement in males in the cotton county was greater than in the whole country, but not for women.

A bookish person exaggerates the importance of reading, but it is surely true that town dwellers, before the days of films and picture papers, who could not read, had little chance of educating themselves and probable that, when a third of adults did not sign their names, the proportion of non-readers was large. The reduction of hours of labour, giving time for literary education, must have had a civilizing effect, and we should reckon this an important item on the credit side of industrial legislation. A century later, we realize that the right use of leisure is of primary importance. A legislative expression of this belief has been seen in 20th-century enactments and orders.

It may fairly be said that, long before the end of the 19th century, conditions within factories, the environment of *working hours*, had been brought up to a standard above those of even the best workplaces in the long war, 1793–1815.

But the general rate of mortality of England and Wales remained until the last thirty years of the century, no better and indeed probably rather worse than in its first fifteen years. William Farr, of course, noticed this and attributed it to the increasing urbanization of the people. He took what comfort he could from the fact that the general rate had not actually increased, as it would have done, if rates prevalent in early 19th-century industrial towns had not improved. But he was always emphasizing the killing power of towns, the positive correlation between density of population and mortality.

Control of domestic sanitation, whether by public opinion or the arm of the law, lagged much more than a generation behind control of conditions in workplaces. In such a book as the late James Niven's 'Observations on the History of Public Health Effort in Manchester' (published in 1923) one has a grim account of Manchester in 1868, of the inhabited cellars, the narrow courts, the privy middens. I content myself with one quotation:

'A vast number of houses are infested by bugs. None of the methods hitherto advocated would seem to meet this plague, which is especially violent in the older parts of the City, as, for example, in Hulme and the Central Districts. . . . These bug-ridden houses are, many of them, not fit for human habitation, but in the present dearth of houses it will be impossible to get all of them condemned.'

I should perhaps add that this passage refers to the Manchester not of 1868 but of 1923.

Some light is shed on the changes of the last half of the 19th century by statistical comparisons. I know that medical readers dislike tables and that the setting of tables is expensive, so I will eschew them. But any interested reader will be able to see the detail in a more technical paper which will eventually be published.

The age of employment at the middle of the 19th century was virtually from the age of 10 years, and perhaps not many could continue after 55 years, so a comparison of the changes in rates of mortality over the range 10–55 should be instructive; textile industries and female lives shall be taken. As no mere ideal but an attained standard, I have taken the rates of the Registration County of Norfolk, which a century ago (and now) stood among the best for low rates of mortality. As the horrid example—following Farr's practice—I have taken the Registration District of Liverpool. For study were selected Blackburn, Burnley and Rochdale. In these three towns, as recently as 1931, more than a quarter of the female population was employed on textiles.

We begin with the girls of 10–15. In the decennium 1851–60 the Norfolk rate of mortality (per 10,000 living) was 559, the Liverpool rate 595, the Blackburn, Burnley and Rochdale rates 525, 620, 547. So that, at the beginning of factory life, the cotton towns (except Blackburn) show no disadvantage. At 15–20, the position is different. Here Liverpool with 716 is better than Norfolk with 785 — perhaps an immigration effect — Burnley, Blackburn and Rochdale with 906, 1045 and 918 worse. At 20–25, Norfolk has 932, Liverpool 948, Blackburn 997, Burnley 1102, Rochdale 995. At 25–35, Norfolk 944, Liverpool 1373, Blackburn 1183, Burnley 1251 and Rochdale 1078. At 35–45, Norfolk has 1090, Liverpool 1877, Blackburn 1491, Burnley 1317, Rochdale 1239. At 45–55, Norfolk has 1207, Liverpool 2686, Blackburn 1796, Burnley 1542, Rochdale 1724. Through half a century these rates improved, but the *relative* positions did not. Improvement in the country has been as fast as, even, on balance, a little faster than in the textile towns. Thus the rates of young girls in Norfolk for 1891–1900 was 268, in Burnley 247, in Blackburn 258, in Rochdale 279, little relative change and the remark applies to the next two age groups. In the age group 35–46, the relative positions in 1851–60, taking the Norfolk rate as 100, were Blackburn 132, Burnley 121, Rochdale 114. By 1891–1900—the Norfolk rate had fallen from 1090 to 770—we reach Blackburn 141, Burnley 127, Rochdale 140. At 45–55 the position is rather worse; in each town the ratio in 1851–60 was less than 150, but more than 150 in 1891–1900.

Like most statistical comparisons in time, this is not a wholly adequate test. Centrifugal movements, suburbanization, have a share. But it is perhaps roughly true to say that our fathers and grandfathers did not succeed in diminishing the gap between town and country workers, in spite of the attraction exercised by towns on the more ambitious and presumably healthier young people.

Our generation, which has suffered two wars, may be tempted to look back on the age of the Old Queen as poets of the Roman Empire looked back

on a golden (mainly agricultural) age. But at least we may claim for this age that the problems of industrial life have been studied as a whole, that it is not only the working hours and the environment of work rooms which are considered the province of the industrial hygienist or legislator.

A casual reader of such a treatise as 'The Factories Act, 1937' (by Maddock and Bellhouse) might possibly think that, except in detail, the modern differs little from the old law. As factory legislation *eo nomine*, is directed to the conditions of the work-place, there must be a close similarity between old and new. But a more attentive reader will notice that hygiene is envisaged more generally and that more effective medical supervision is required than before. The increased responsibility of the Local Authority is of great importance, because it means that, for some important purposes, the Housing Authority and the executive Factory Authority will be identical. In other words, it is no longer true that home and factory are supervised by officials who have no mutual responsibilities. The result is that social legislation and administration are coming to be regarded as a whole. No doubt the synthesis is far from complete. At the beginning of this war, many mistakes of the last war were repeated because knowledge of past experience had not been disseminated, but, without facile optimism, we may believe that the future is promising.

SOME ASPECTS OF SICK ABSENCE IN INDUSTRY *

BY

H. H. BASHFORD

(From the Post Office Medical Branch)

Though the Post Office must not be taken as representative of industry as a whole, it is, numerically speaking, the largest single industrial concern in the country, and probably the most various. Thus it has many thousands of outdoor manual workers in its postmen, engineering linesmen and skilled workmen; many thousands of indoor manual workers in its sorters, porters, telephonists and telegraphists; many thousands of clerical workers, both men and women, in its large administrative and accounting offices and in the Savings Bank and Money Order Departments; a considerable motor transport section; stores and factories departments; wireless operators, research workers, and the seamen in its cable ships. As an industrial medical service, that of the Post Office goes back to the middle of the last century and is probably the oldest and certainly the largest that we have.

It differs, of course, from most outside industries in that every established postal servant under a certain salary, is entitled to free medical service from the Department; and it differs also in that the great majority of its staff are established civil servants on a non-contributory pension basis, who receive annual leave with pay, and who also receive if they are away ill, full pay for six months, half pay for six months, and pay after that at pension rate, if they have given ten years service—provided that there is a reasonable prospect of recovery to render regular and efficient service in the future.

In order to determine the latter, the Post Office relies on its medical advisers—its whole-time headquarters staff of medical men and women, and its local Post Office doctors, who are general practitioners holding local Post Office appointments. There are about 2600 of these all over the country, and they attend the local staffs entitled to free medical attention, on a capitation basis, examine local candidates for Post Office employment, inspect and report each year on the sanitation, ventilation and general condition of the Post Offices and Telephone Exchanges in their area, and advise local Head Postmasters, Telephone Managers and other controlling officers on matters connected with the health of the staff. Each of them sends in an annual report to the Chief Medical Officer.

There is probably, therefore, in the Post Office, both in the way of actual treatment and the medical supervision of health and illness, a closer association with the staff than has yet been established in most other industries; and accurate sick records are kept of every Post Office employee, whether established or unestablished, for the whole of their Post Office careers—often from the age of 14 to the age of 60. These are all readily available for any Post Office medical adviser, who may be asked to treat or to report upon any particular employee; so that he can see, at a glance, what has been the medical history during the last 5, 10, 20 or more years. These sick records are, in normal times, assembled and classified every year; so that we can obtain the average annual sick rate for the whole Post Office staff, average annual sick rates for all its component groups, and in addition, the average annual sick rates for each of the big cities and very many smaller towns. This enables useful comparisons to be made between one year and another, between one group of workers and another, and between groups of workers in various parts of the country. It also enables, if anything abnormal emerges, inquiries to be made and appropriate measures suggested.

But, apart from this annual review, the whole process of medical supervision, centralized at headquarters, is continuous throughout the year. Cases in which so many sick absences have been incurred in any twelve months, in which some particular illness has lasted for such and such a time, are automatically referred by the relative controlling officers for medical advice; and there are scores of others which, for some reason or another, have come under medical notice, in which sick records are reviewed again in three months' or six months' or a year's time as the case may be, and here it should be added that all these medical reports and advice are regarded as strictly confidential. Further, and apart from the help which, it is believed, these accurate sick records enable the Medical Branch of the Post Office to give both to the staff and the department, they provide an immense and invaluable basis for the following up, on a large scale and over a very long period of the effects on working capacities of many disabilities—real or supposed—of various forms of treatment, both medical and surgical, and a useful guide to the worth or other-

* Based on a Paper read at Manchester University, January 17, 1943.

wise of those changing fashions, fads and fancies from which Medicine is, alas, not wholly free.

If, therefore, stress is laid upon these individual sick records, it is because they are the first and absolutely essential requisite in any really effective approach to the problem of health, happiness and efficiency—the all-important human factor—in any industry, whether great or small. Without them no management or medical adviser has the real information upon which to introduce a reform or lay down a policy, and it is perhaps a little surprising how very recent, and how very partial, has been the realization of this by industry as a whole.

Not many years before this war an endeavour was made, for purposes of comparison, to obtain some idea of their sick rates from several very large industrial concerns, but most of them replied that they had no such figures. Some of them, on the grounds that they did not pay their people when they were ill, frankly said that the question did not interest them and was not in their opinion worth the clerical labour that would be involved. There were a few exceptions such as Imperial Chemical Industries, the L.M.S. railway and various other firms who had begun to do so and were already employing whole-time doctors. But they were in a relatively small minority. Since the war, however, there has been a great increase in the number of industrial concerns and factories employing whole or part-time medical advisers and also, it is to be hoped, beginning to keep regular and accurate sick records.

With this foundation, any such firm has, at any rate, begun to get the primary data for comparing the health of their people from year to year; the health of those engaged in one process with those employed in another; and, even more important, the data for discovering where the bulk of their sick absence resides. This is usually in a minority group and particularly so in the case of multiple short sick absences for minor complaints, and it is perhaps in this field that the industrial medical adviser or works doctor can be most useful not only to his firm but to the staff under his care. And here emphasis should again be laid on the fact that malingerers and malingering—in the true sense of the words—are exceedingly rare in Post Office experience. During the 27 years of clinical work, in which about a quarter of a million patients were seen and some 14,000 visited, the present writer met with scarcely a dozen cases. There were a few people who developed convenient headaches or the like on the day of an important football match, and no doubt some of the alleged sufferers successfully got away with it. In fact some of them, in their maturer years, have admitted that they did. But this is inevitable and very human and its effect on total sick absence is negligible. There is, of course, the group of the neurotics or potential neurotics, but they are not malingerers; and there are many young people who may light-heartedly—and on rather semi-medical grounds—incur a good many short sick absences in a year. When confronted in black and white with their own sick records, many of these are quite genuinely surprised; and a friendly talk with the medical adviser often results in a complete alteration for the better. Others, again, may be found to be suffering from some remediable disability such as carious teeth or septic tonsils and attention to these may again at once alter the complexion of their sick records. But there is yet another group, both of young and old people, in which the real underlying trouble is some private anxiety or unhappiness, some real or fancied grievance, some inherent dislike or fear of a particular task or part of it, or some temperamental strain in respect of a colleague or overseer. The works doctor, if he is wise and sympathetic, if he holds—as he should hold—the confidence both of the staff and the management, can do an immense deal to adjust or dispel all this. A change of work or a change of room, even the mere unburdening of the hidden trouble, can produce a quite disproportionate result in terms of health and happiness; and this is surely preventive medicine in one of its most real and practical forms.

All this is work, too, that it would be very difficult for a panel or private doctor to do quite as well, even if he could do it at all. It is true that he may know more about the worker's domestic circumstances and perhaps as much about his physical and mental make-up. But it is the industrial doctor, with the actual sick record before him, with his inside knowledge of the factory or office and their populations, who can—preferably in association with the panel or private doctor—most capably deal with this aspect of the problem.

But even more perhaps than medical supervision —as any experienced industrial doctor can testify— is the influence upon sick rates of what may be called the atmosphere, in the spiritual sense, of an office, department or works, and this is largely, almost supremely, dependent upon the management itself and the sort of supervisors, foremen or forewomen, whom it chooses. Health and happiness are fortunately as infectious as—indeed more infectious than—disease; and the right sort of supervisors, masters of their jobs but also themselves healthy, sympathetic, really interested in their fellows, and with the golden capacity of being blind at the right moment, can perhaps do more to reduce sick absence than any other single factor. As an illustration of this, some recently published figures may perhaps be referred to. They concern five groups of men and women all working in the same office.

AVERAGE ANNUAL SICK ABSENCE IN DAYS

	Men			Women	
1st year	15·0	15·4	14·7	24·5	25·8
2nd year ..	16·7	14·1	23·5	35·1	39·8
	Change of lay supervision				
3rd year	8·0	6·9	13·2	22·1	12·9
4th year	7·0	7·3	13·0	14·3	10·7

As was mentioned at the time, the change of lay supervision was not the only factor in this transformation. But it was undoubtedly the principal one, the conversion of the office into what the sailors call a happy ship, and no amount of up-to-date gadgets, or the best equipped welfare rooms in the world will make up for the wrong sort of management or supervisors. And here perhaps another small point may again be mentioned. In every concern there must be rules and regulations. But it is not everybody in those concerns who understands the reason for them, and this lack of understanding may occasionally cause in somebody's breast a certain amount of smouldering resentment. Everybody in authority, therefore, should not only know the origin and purpose of those rules but be ready, if necessary, to explain them without feeling that their personal dignity is affronted. And since rules and regulations may outlive the circumstances that produced them, they should always be prepared, at least, to consider their modification.

Turning to some more general aspects of health and sickness in industry, there are a few basic considerations which should always be borne in mind by managements and their medical advisers, and one of these is the age composition of the staffs employed. In Post Office experience, careful observations over many years have gone to show that men over 40, as a group, incur 55 per cent. more sick absence than men, as a group, under 40; and women over 40, as a group, 58 per cent. more sickness than women under 40. The younger people incur more sick absences but these, as a rule, are of shorter duration. Then again women, as a whole, tend to incur more sick absence than men—in our Post Office experience about 10–17 per cent. more. This, of course, has a particular significance at the moment. Apart altogether from war conditions, as the proportion of older men to younger, and of women to men, increases in any works or office, there must be a normal expectation of an increased average sick absence rate. As regards causation, it is a general experience that the catarrhal and respiratory group of diseases is usually the largest; and in the Post Office it has been usually responsible for from 20 to 30 per cent. of our total sick absence; and this applies both to men and women. Digestive disorders account, both amongst men and women, for about 10 per cent. of our total sick absence, and we ourselves have found, as regards men, that the sick rates of the outdoor staffs tend to be rather higher than those of the indoor staffs. This is not necessarily because they are less healthy. But there are certain respiratory and rheumatic affections that might not prevent an indoor worker from carrying on but which might temporarily disable a telephone linesman or a postman.

As regards a normal annual average sick absence rate, it would be very difficult to dogmatize, especially in present circumstances; and in comparing one industry with another their respective natures and the age compositions of their staff would, of course, have to be considered. But based upon Post Office experience, for a mixed staff of manual, clerical, outdoor and indoor workers under 25 years of age, a peace-time figure of about 5 days for the men and boys and 6 days for the women and girls would not probably be far wrong or enough to cause anxiety. For a whole mixed staff with, say, about a quarter of its men over 50 and a quarter of its women over 40, 8 or 9 days for the men and 9 to 11 days for the women would probably be somewhere near the mark in normal peace conditions. At any rate, something like these figures might serve as a datum line from which managements and their doctors could set out to study their own individual problems.

So far nothing has been said about war conditions, but if the study of sick absence is of the highest importance in industry at all times, it is surely even more so in a nation at war or facing the problems of its aftermath, and unfortunately, as regards the country's industries at large, there is rather a paucity of available figures. But if the 260,000 odd Post Office population is any sort of a barometer, there has not so far been evidence of any serious deterioration in health. In certain large cities, indeed, sick rates have been actually lower than in the three years immediately preceding the war. Amongst workers in other places, and particularly women workers—and particularly again in the more heavily bombed areas—there has been an increase.

But it has not been possible—apart from the direct effects of bombing, with its dislocation of travelling, loss of sleep, and added domestic stress—to disentangle any particular war factor that has definitely influenced sick rates. There are, for example, a good many workers who have been obliged, for long periods, to do their jobs in basements. But it has not been shown, given adequate lighting and ventilation, that basement working *per se* has been detrimental to health. Up to now the rationing of foodstuffs has not visibly affected working capacity; and this is also true of night work. Where the Post Office has experienced, apart from air-raid activity, a marked rise in sick rates, this has probably been mainly attributable to longer working hours and the curtailment of annual holidays, and particularly in certain of our departments where the work has demanded close attention and accuracy, but has been inevitably of a somewhat monotonous character. But even amongst these staffs, the extra days lost by sick absence have been a mere fraction of the extra days worked, as represented by longer working hours and abridged annual leave. And the Post Office system of sick record keeping is enabling the position to be closely watched.

In a few large departments in London, which were seriously affected by prolonged bombing, travelling difficulties and loss of sleep—and where the sick records began to show a danger signal—various measures were taken, such as improving canteen facilities, the staggering of meal hours, and the better provision of sleeping facilities on the premises for late evening and early morning

workers; and this was followed by an immediate fall in sick absence.

Finally, it is now probably true that, whatever their school of political or economic thought, those responsible for management in industry have fully come to realize that the men and women and boys and girls in the nation's workshops deserve at least as much care and attention as the equipment, which, would be useless without them. The real question is how this can best be fulfilled. A few not very new suggestions have been made; and if one more has been left to the last, this is because it is feared to be impracticable. But it has been found, particularly during the war, that in the smaller Post Office offices and exchanges it is very much easier for those concerned to realize the importance of their work. They are members of a family and not of a crowd; and if they are away they are really missed and they know it. In the larger offices and exchanges, it is harder for employees to feel this. If they are away for a day or two, it does not, at any rate, seem to matter so much.

But it is probably hopeless to expect smaller units in industry; and a great deal can be done—and is, of course, already being done—to try to foster the family spirit in the larger units. But there is one small point that perhaps might be mentioned. Managements and managers, roughly speaking, are the successes in industry. Working under the same roofs with them, are many scores of men and women, of no more than average ability, who can never expect to become this or who have seen what dreams of promotion they may once have had gradually disappear and die. But industry is not the whole, or even perhaps the best part of life. There are such things as music and painting and gardening and games. And it may be an admirable thing, from a great many points of view, for the chairman to be beaten at bowls by the stoker; or for the able young head of a department to discover, at a works concert, that he isn't in the same street with the elderly dud in the corner of the drawing office.

CHRONIC CARBON TETRACHLORIDE INTOXICATION

BY

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Carbon tetrachloride is a non-inflammable, cheap and easily available fat solvent. The majority of cases of poisoning reported have been isolated incidents, following temporary exposure to high concentrations of the vapour or oral administration of liquid carbon tetrachloride in the treatment of disease. In such cases death may result from narcosis, hepatic necrosis or acute nephritis but if the victim survives, little or no permanent damage ensues. There has been little reason to suppose that workers in contact with carbon tetrachloride suffer any deterioration in general health, so long as precautions to prevent heavy exposure have been taken in designing the plant. This opinion appeared to be confirmed by the investigations of Smyth and Smyth (1936) among workers employed in thirty-six factories using carbon tetrachloride. They made a careful analysis of air concentrations of the solvent and carried out a series of blood counts, and liver and kidney function tests, on ninety-six workers who had been employed over several years. They concluded that their tests showed that no one could be considered seriously or even unmistakably injured by the solvent vapours.

It was therefore a matter of considerable interest when we were asked to carry out an investigation in a chemical factory where large numbers of workers were said to be suffering from chronic carbon tetrachloride poisoning. Although only 75 people were working at any one time in contact with carbon tetrachloride, 122 certificates for compensation had been issued over a period of two-and-a-half years and more than 80 people had been discharged because of symptoms attributed to carbon tetrachloride. The work was acquiring an evil reputation in the district and it was becoming increasingly difficult to obtain labour to replace the losses. In addition the management was perturbed by failure to maintain a satisfactory rate of production. In work of this kind efficiency can be measured by the ratio between output and input of chemicals. In a new process it is customary for the ratio to rise sharply at first as the technique is mastered, and thereafter to maintain a slight upward trend. In this particular process the numerical value for efficiency had actually declined. This was attributed to the failure of shift managers and key personnel to maintain enthusiasm or even carry on at all after six to eighteen months in contact with carbon tetrachloride.

Details of Investigation

The process consisted in the chlorination of an aniline derivative in solution in carbon tetrachloride. The factory had been planned for continuous work under conditions of war, and more attention had been paid to the strength of the walls and the completeness of the black-out than to the state of the atmosphere. Apart from the difficulty of general ventilation, high concentrations of carbon tetrachloride were liable to occur from spills of material and from leaks in the piping system which connected the separate containers or conveyed the mother liquor from the sump tank back to the still house. Such leaks were inevitable owing to corrosion of pipes by traces of hydrochloric acid and the solvent action of carbon tetrachloride on the washers of joints and pumps. The chlorinated compound was eventually separated from the carbon tetrachloride by centrifuging and vacuum drying and during these processes an ill-fitting lid or an inefficient draught was enough to contaminate the atmosphere heavily. No useful figures can be given for the air concentrations of carbon tetrachloride. Although the chemists used the Halide Detector Lamp over a period of three months, it did not work satisfactorily and if a serious leak occurred, no one was free to take a reading. At first it was thought that the high morbidity rate might be due to some other chemical used in the process. But an analysis of the air concentration of the various substances and a comparison with other processes in the factory, where they were used without carbon tetrachloride, indicated that carbon tetrachloride was the offending agent. This conclusion was supported by the fact that the symptoms were similar to those described in the literature in mild forms of carbon tetrachloride poisoning and they were different from the known effects of the other chemicals.

Approximately 25 workers per shift were engaged on the plant and work was continued throughout the 24 hours on a three-shift basis, so that about 75 people were involved each day. Workers were often transferred to other parts of the factory so that the total number of people who had been exposed exceeded this figure. During the investi-

gation we succeeded in interviewing and examining 78 of the factory employees: 51 of these were working on the carbon tetrachloride plant at the time of the examination and 27 were engaged on other processes but had been exposed previously. As many as possible of those examined were persuaded to have venepuncture and special investigations such as test meal, barium meal, gastroscopy and a detailed examination of the eyes by an ophthalmologist. The tests made on the sample of venous blood included a full blood count, erythrocyte sedimentation rate, blood urea, serum bilirubin and phosphatase, plasma proteins and the Takata-ara test for liver efficiency. Technical methods are described in a previous paper (Higgins, O'Brien, Stewart and Witts, 1943).

Another effect of exposure that had attracted the attention of the factory surgeon was a remarkable gain in weight in the women as soon as they began to work in the plant. When we came to examine the cases we found several instances of a gain of over two stone in a few months. This effect was most common in the women but was also found in a smaller number of the men.

Gastro-Intestinal Effects

The severity of the gastro-intestinal symptoms varied from a mild queasiness to violent and repeated attacks of nausea, vomiting, colic and diarrhoea. The more severe symptoms always followed a particularly heavy exposure such as might occur while attending to a big leak or spill. It was therefore characteristic for the symptoms to be recurrent rather than steadily progressive, though it was common for subjects to find that, whereas in the early weeks or months of exposure they felt well between the severe bouts, sooner or later they developed residual effects such as persistent nausea, alterations of appetite with a perverted sense of taste and smell, and a vague fullness in the epigastrium or dull ache in the lower part of the abdomen. Gradually they acquired such a distaste for the smell of carbon tetrachloride that they experienced attacks of vomiting in circumstances which had previously had no effect. In some cases sensitivity was heightened to an amazing degree. One of the fitters declared that he was unable to wear his gas-mask because the smell of it induced vomiting immediately. A plant chemist volunteered the remark, 'I have now developed a conditioned reflex and the thought of setting about a job which involves handling the stuff is enough to make me vomit.' Others who had observed the same effect were convinced that their vomiting was now psychological, a possibility which was suggested on other grounds. It could not be supported as a total explanation, however, after one had considered the personality and record of many of the people. A few workers behaved in a different way. They remembered having had nausea and vomiting in the early days of exposure but in the end became immune and no

TABLE 1

Group	Sex	Exposure in months	Interval in months since last exposed	Total	Bio-chemistry	Barium meal	Test meal	Gastro-scopy	Eyes
I	Males ..	2–36	0	37	28	16	16	11	13
	Females ..	1–20	0	14	10	3	1	2	2
II	Males ..	2–24	1–20	10	8	5	3	1	0
	Females ..	1–6	1–14	17	14	1	0	1	0

Number and sex of workers examined by various techniques. All were examined clinically. Workers in Group I were employed on the carbon tetrachloride plant at the time of examination. Those in Group II had been previously exposed but were now employed elsewhere in the factory.

Apart from one case of acute rheumatism, with aortic and mitral disease, two cases of essential hypertension, four cases of chronic bronchitis and emphysema, together with a fairly high incidence of minor defects such as gingivitis, dental caries, chloracne and folliculitis, clinical examination of the workers was essentially negative. It was a striking thing that despite the severity and duration of their symptoms the subjects had the appearance of good health. Their appearance almost belied their story. However, a typical history of symptoms resulting from exposure to carbon tetrachloride was obtained in every instance except one. The exception was a woman who had only recently been recruited to the work and had as yet experienced no ill effects. As the histories were related it soon became clear that there were two sharply differentiated sets of symptoms, one which indicated a gastro-intestinal disorder, and the other a cerebral disturbance. The certificates compiled by the factory surgeon contained the following list of complaints:

Nausea	110	Weakness	12
Vomiting	122	Vertigo	21
Anorexia	64	Collapse	4
Abdominal pain ..	78	Confusion	2
Diarrhoea	97	Headache	8
Haematemesis ..	5	Cough	1
Haemorrhage from rectum	1	Dyspnoea	1
		Loss of weight ..	2

longer suffered any ill-effects except when heavy contact with the fumes caused temporary giddiness and a feeling of intoxication, a narcotic rather than a gastro-intestinal effect. These workers were able to work in conditions considered intolerable by the others.

It was usual for subjects to experience nausea immediately after a period of heavy exposure but frequently vomiting was delayed until after the next meal and the attack often reached its climax after 24 hours, by which time, in severe cases, there might be extreme prostration with salivation, chilliness and shivering. On such occasions the vomit often contained streaks of blood and there was usually severe colic and diarrhoea.

Bowel symptoms were often most conspicuous in the first serious episode and might not be repeated in subsequent attacks. In two cases, however, they were the predominant feature and diarrhoea persisted for several weeks after the other symptoms had subsided. A mild recurrent form of diarrhoea was a very common residual effect, and it was significant that no single person working on the plant admitted to being constipated, though several had suffered in this respect before taking up their present work. Abdominal pain during the acute attacks was of two types and a worker might suffer from both or only one. Colic was both upper and lower abdominal and was of all grades of severity. The other type of pain was epigastric in situation, aching or burning in character, and persisted for longer periods than did the colic. It was described by one as grasping pain, by another as like a belt which is too tight. Though the liability to attacks increased, the severity usually did not, and one gained the impression that in spite of recurrent episodes there was no continuous deterioration in the general health. Even the residual symptoms that stretched from one exacerbation to the next were rapidly relieved after a brief period away from work.

Certain things accentuated the symptoms both between attacks and at the height of an episode. Many were found to be avoiding fat foods because they brought on nausea. Pickles caused pain. Milk, which was supplied freely and in abundance, was soon left untouched. Experienced workers never had beer before coming on a shift but one chemist said any long drink had a bad effect. Tobacco often heightened the nausea or the pain, and many experienced dizziness, palpitations, a feeling of coldness and even collapse when they smoked immediately after a shift. One intelligent young woman commented that the feeling carbon tetrachloride gave her was just like the feeling of being pregnant. 'You want to eat, but when you do, even a cup of tea tastes somehow different.'

Mental Effects

Temporary cerebral effects, such as light-headedness, giddiness and vertigo occurred immediately after exposure to high concentrations of carbon tetrachloride vapour, though there was considerable personal variation in the threshold at which symptoms appeared. A few individuals had lost consciousness whilst attending to leaks or spills. Acute headaches usually followed these events and a more chronic form of headache was found in several cases. Alteration of the sleep rhythm was as universal a complaint as were the gastro-intestinal effects. Drowsiness and failure to feel refreshed on waking were invariably present. Some said they could sleep the clock round and still want more; others, equally drowsy, had insomnia. Frequently one phase alternated with the other and in such cases temporary insomnia was often associated with the bouts of sickness. Excessive fatiguability as well as drowsiness was commented on by all.

The next commonest effect was a loss of mental agility which showed itself in inability to tackle more than one problem at a time and impatience with anything which demanded spontaneous enthusiasm. As might be expected, the mental hebetude which occurred as a result of exposure was more clearly described by the plant chemists and skilled workers than by the process hands. More than one plant chemist had noticed a time lag between thought and decision, and there was a tendency to loss of memory for recent events. Depression and irritability had often been remarked by the subjects. Inertia was such that one had diagnosed his complaint as pure idleness. Several said that they used to be voracious readers but were now liable to fall asleep over a book, or had such difficulty in following the plot and remembering fresh names, that they had given up reading books and only occasionally looked at the newspapers.

The need to clean and cook appeared to help the women, who were responsible for the care of their homes, to throw off the inertia which they felt as a result of contact with carbon tetrachloride, and several of them explained that a sleep of from half an hour to two hours immediately on returning home, before attempting to eat, made them feel fit enough to tackle household duties. Almost all workers interviewed said that they felt too lazy between shifts to make the effort to go out for air or exercise though they knew it would be good for them. As one man put it 'The worst of the stuff is that it stops you doing what you know would do you good against it; you turn against milk and you can't be bothered with getting out of doors.' This comment came from a worker who had fished all the rivers within a radius of 40 or 50 miles and knew in which the fish had survived the by-products of industry. After a few months on the plant he had completely dropped a hobby which had kept him sane all through the depression.

Other men, who had cultivated allotments during the same period, wished to keep them going but said they felt too lazy to make the effort after working with carbon tetrachloride. Many of the younger workers housed on a new estate had not even begun to get their gardens in order, but there was no means of knowing whether this neglect was more common

among these workers than among other residents. The visitors had the impression that in spite of the opinion which most workers expressed that fresh air got rid of the effects of carbon tetrachloride and also that carbon tetrachloride and beer 'don't agree,' the workers often spent leisure time in the cinemas and public houses because it required less effort to do so than to get out for air and exercise. Nevertheless the speed with which symptoms disappeared when workers were removed from the plant was surprising. Almost all reported that a week-end away, especially if it was spent in exercise in the open air, caused great improvement in both mental state and gastro-intestinal symptoms. Even a long bicycle ride or a game of golf made a striking difference.

Haematological and Biochemical Data

Venous blood samples were obtained from 36 men and 24 women. The area from which the workers were drawn had suffered severely in the depression. For the ten years preceding the war there had been a great deal of unemployment and in some cases the unemployed were not reabsorbed into industry for twelve or eighteen months after the outbreak of war. Red cells and haemoglobin in both sexes are some 10 per cent. below the accepted standard of normality (Price-Jones, Vaughan and Goddard, 1935) but they are not significantly different from values obtained in nutrition surveys of comparable areas in 1942. The lowest haemoglobin value in a man was 81 per cent., but four of the women had haemoglobin values below 80 per cent.—79, 77, 71 and 67 per cent. respectively. The colour indices were unity or below. White cells are above the normal mean for venous blood, which Osgood, Brownlee, Osgood, Ellis and Cohen (1939) gave as 7410±70. Sedimentation rates also are higher than Wintrobe and Landsberg's (1935) normals, but they are not very different from a group of controls from other sections of the factory. There is still a great deal to be learnt about the frequency distribution of haematological data in factory populations, but we feel justified in saying that there is no pathognomic change in the blood count of the carbon tetrachloride workers. The blood urea, the serum bilirubin and phosphatase, and the plasma proteins were all within normal limits. No individual value was significantly different from the normal, and the Takata Ara reaction was negative throughout. The total fats, fatty acids and cholesterol of the plasma were determined in 9 men and 12 women and these also were normal.

TABLE 2

	No.	Hb, per cent.	R.B.C., millions	C.I.	W.B.C., thousands	Reticulocytes, per cent.	E.S.R., mm.	Platelets, thousands
Males ..	37	95±1·14	4·97±0·02	0·97	10·2±0·54	1·07±0·1	9·0±1·22	247±3·21
Females ..	24	86±1·57	4·6±0·1	0·93	9·1±0·52	1·49±0·11	18·5±2·6	284±17·8

Blood picture in chronic carbon tetrachloride intoxication. In this and subsequent tables the statistical averages are given ± the standard error of the mean.

TABLE 3

Group	Sex	No.	Mean, mm.	Range, mm.
Medical students and nurses (Wintrobe)	Males	137	3·7	0–14
	Females	100	9·6	0–29
Carbon tetrachloride workers.	Males	36	8·5	1–32
	Females	24	18·5	3–45
Unexposed workers from same factory.	Males	30	8·2	1–24
	Females	19	11·0	4–31

Erythrocyte sedimentation rates in workers compared with normal men and women controls from the same factory.

Barium Meals

Barium meals were performed on 25 subjects, 19 at present employed and 6 formerly employed on work with carbon tetrachloride. No one was seen during an acute attack of sickness but three subjects

TABLE 4

	No.	Blood urea, mg. per 100 c.c.	Bilirubin, mg. per 100 c.c.	Phosphatase, King and Armstrong units	Proteins, g. per 100 c.c.			Takata-ara
					Total	Albumin	Globulin	
Males ..	37	33·8±0·96	0·43±0·04	9·6±0·49	7·01±0·05	4·5±0·04	2·53±0·1	Negative
Females ..	24	30·0±1·17	0·38±0·08	9·1±0·7	6·99±0·06	4·43±0·04	2·53±0·6	Negative

Biochemical data in carbon tetrachloride workers.

TABLE 5

	No.	Total fats, mg. per 100 c.c.	Fatty acids, mg. per 100 c.c.	Cholesterol, mg. per 100 c.c.
Males ..	9	608±45	346±40	143±9·8
Females ..	12	564±52	380±63	156±8·4

Total fats, fatty acids and cholesterol in the plasma of carbon tetrachloride workers.

had some abdominal pain at the time of the examination and two had had a severe attack of vomiting a few weeks previously. The changes observed under the screen were similar in all the subjects examined. They were present even when there had not been any recent exposure, though the changes were then less marked. The abnormal features have been listed in Table 6. They consisted of a characteristic change in the motility and appearance of the stomach and intestines, which suggested an unusual state of irritability and was shown chiefly by spasm of various parts of the gut and a rapid passage of the meal during the first six hours.

In all cases the stomach was of good tone and in three it was noticeably irregular in the prepyloric area. Four of these cases were examined with the gastroscope and this examination failed to reveal any evidence of ulceration which might have accounted for the appearance under the screen. Generally the mucosal folds were normal but in 7 cases they were less plastic than usual and the rugae appeared unduly prominent. In one of these the whole stomach seemed stiffened as though it had been infiltrated by some process that was impairing its normal elasticity. This appearance of thickening and irregularity of the wall with visible mucosal pockets was similar to that described with localized areas of chronic gastritis, but here again gastroscopy failed to reveal any abnormal surface changes.

The duodenal bulb was frequently abnormal. In no less than ten cases it was described as spastic and in six instances it was so exceptionally small that it gave the appearance of being in permanent tonic contraction. In addition, the mucosal folds of the bulb and the duodenal loop were often thicker and more rigid than usual. In spite of these appearances there was only one definite duodenal ulcer. This was seen as a small niche in the centre of the posterior wall.

Changes in the small bowel were present in nearly every case, for even where there was no irregularity or spasticity of the coils, there was hypermotility. In several cases the head of the meal was in the ascending colon at the end of one hour and in two cases it had reached the hepatic flexure. The changes in the mucosal pattern were not necessarily present throughout the whole of the small bowel. In some cases they were most marked in the duodenum and diminished in intensity towards the proximal coils of the jejunum. In others they were most severe in the terminal ileum.

Hypermotility was continued through the large intestine and in several instances the head of the meal had reached either the sigmoid colon or rectum at the end of six hours. Spasm of the colon was a conspicuous feature in all the cases in Group I but was absent in five of the six cases in Group II and in two of these cases the meal had only reached the hepatic flexure at the end of six hours.

TABLE 6

	Group I (19 cases)	Group II (6 cases)
STOMACH—		
Hypertonicity	3	1
Prominent or rigid rugae ..	6	1
Excessive secretion	8	0
Pylorospasm	14	3
Irregular peristalsis	5	0
DUODENUM—		
Spastic cap	8	2
Ulcer niche	1	0
Irregularity and spasticity of loop	7	2
JEJUNUM AND ILEUM—		
Irregularity and spasticity of coils	11	2
COLON—		
Spasticity: (1) Severe ..	14	0
(2) Moderate ..	5	1
HEAD OF THE MEAL AT 6 HOURS—		
(1) Hepatic flexure	0	2
(2) Splenic flexure	5	2
(3) Sigmoid colon	10	1
(4) Rectum	4	1

Radiographic findings in workers at present employed (Group I) or previously employed (Group II) in contact with carbon tetrachloride.

Fractional Gastric Analysis

Fractional test meals were carried out in 20 cases. The gastric stimulant was a pint of unsalted gruel and the secretion was followed for two-and-a-half hours. Judged by the standards of Bennet and Ryle (1921) hyperchlorhydria was present in 11 cases and hypochlorhydria in 3 cases. An excess of mucus was found in 3 cases. The most severe hyperchlorhydria was found in a man who had had a heavy exposure with severe nausea and vomiting five days before. Other examples of hyperchlorhydria were also associated with recent exposure. The group was comparatively small but it is striking that more than 50 per cent. showed excessive secretion of acid, in contrast to the 10 per cent. that might be expected, especially as many of them were middle-aged and elderly people. All the subjects with marked hyperchlorhydria showed considerable radiological changes, but these were also found in the presence of hypochlorhydria.

Gastroscopic Examination

Gastroscopy was carried out on sixteen workers, all of whom had also had a barium meal and follow-

through examination. The examination was made with the Hermon Taylor gastroscope except in one man who had a slight scoliosis which necessitated using the Schindler gastroscope.

In nine cases there were well-marked disturbances of the musculature. The stomach was very tonic and did not allow easy inflation. The entrance to the antrum had a mouth-like appearance with the mucous membrane thrown into folds at its edge. It relaxed very slowly after inflation, and sometimes not at all. In two cases the mucous membrane of the antrum lay in longitudinal folds. Peristalsis was seen in half the cases, but in one the waves moved very slowly and passed only half-way up to the pylorus. Multiple rings of spasm were sometimes seen in the body of the stomach. The final impression was that the stomach was tonically contracted and unduly liable to intense and prolonged spasm.

In eleven cases, five of which had shown disturbances in tone, the mucous membrane was normal. In five the membrane was hyperaemic with a slight excess of high lights suggesting oversecretion or oedema. In eight cases there was a variable amount of exudate in the body of the stomach. This exudate was usually of the light frothy type, but in one case with a hyperaemic mucosa thick adherent mucus was seen in the antrum and lower part of the stomach, and cloudy bile-stained mucus was seen pouring back through the pylorus, carrying with it lumps of thicker yellow-white mucopus. X-ray examination had revealed considerable irregularity of the mucosal pattern in the duodenum. In one other case, though the mucosa was normal in appearance, a small amount of mucopurulent exudate was seen in the region of the angulus. The largest amount of the white frothy exudate was seen in an individual who had had an attack of nausea and vomiting a few days previously and still had slight abdominal pain. Here the mucosa was normal but the angulus and sphincter muscle of the antrum were in intense spasm and the mucous membrane round it was thrown up into longitudinal folds.

The mucosal changes varied in type, occurred only in a minority, and with one exception were never severe. They represent minor degrees of gastritis and neither in incidence or severity are they more than might have been expected in any group of men or women of this age and class. On the other hand, the gastroscopic findings which have reference to the muscular wall of the stomach were all of the same type and occurred in over half the cases. They constitute the positive result of the gastroscopic investigations and are unusual findings. They support the conclusion that the gastric symptoms are the direct result of a motor disturbance, which may occur without any recognizable gastritis. The discovery of mucopurulent exudate in one case raises the suspicion that where disturbances in tone and secretion are continued for long periods they may eventually exert an irritant effect on the gastric mucosa.

TABLE 7

Examination	Group I	Group II
TEST MEAL—		
Number of cases	19	1
Total acid	66±5·0	12
Free HCl	56·5±6·5	0
GASTROSCOPY—		
Number of cases	13	3
Tone: (1) Normal	5	2
(2) Increased ..	8	1
Mucosa: (1) Normal ..	9	2
(2) Hyperaemic ..	4	1
Exudate: (1) Nil	6	2
(2) Frothy ..	5	1
(3) Mucopurulent	2	0

Test meal and gastroscopic findings in carbon tetrachloride workers.

Examination of the Eyes

The fifteen cases examined from the visual point of view were submitted to the following tests:

1. Visual acuity without glasses, and with glasses when worn. If vision failed to improve to normal, the refraction was checked and vision recorded with an accurate correction.

2. Fields of vision recorded on the Lister Perimeter with a ¼-degree white object.

3. Investigation of the central field both for white and colours, Bjerrum Screen.

4. Ophthalmoscopic examination.

5. Ishihara test for colour vision.

The results can be summarized as follows :

(*a*) All cases had normal visual acuity, either without glasses, or with glasses where necessary.

(*b*) In all cases but one the fields of vision were full.

(*c*) All cases but one showed no scotomata and no enlargement of the blind spots and no scotoma for colour.

(*d*) Fundi were normal in all cases.

(*e*) All had normal colour vision save one, who had partial red-green deficiency. This he had always been aware of.

The one case who showed on the perimeter test a loss of field in the lower nasal quadrant of the right eye, on the Bjerrum Screen was found to have an arcuate scotoma arching downwards from the blind spot to the nasal side. Visual acuity was normal, and central colour perception acute. This man was 41 years of age and had been unaware of any visual disturbance. The field defect was rather suggestive of early chronic glaucoma, although there were no other signs. It was certainly not suggestive of any toxic condition.

Follow Up

Examination of the factory records revealed the fact that though no deaths had occurred from acute carbon tetrachloride poisoning, one male worker had died from a perforated gastric ulcer, one had been operated on for acute pancreatitis, five cases had developed albuminuria and one case had been

found to have a large liver. In addition 86 individuals had been discharged for gastro-intestinal symptoms ascribed to carbon tetrachloride. The names and addresses of these individuals were obtained and an attempt was made to get in touch with as many as possible. In the end we succeeded in tracing three of the cases of albuminuria (two had left the district), the case of acute pancreatitis and the case of hepatomegaly, and they all attended for medical examination. In addition 54 houses were visited and 30 of the individuals discharged for sickness were seen in person by the health visitors. A specimen of urine was obtained from each. Six houses were empty and no further information was forthcoming. In 18 cases, though the individual was out at the time of the visit, it was ascertained from a neighbour or relative that he was either working full time or had joined the forces. No case of albuminuria was found amongst the 30 cases successfully visited and only six were not back at full-time work.

Two of these ascribed their ill-health to carbon tetrachloride sickness and were seen by the doctor. One had only left two weeks previously after a severe bout of vomiting and was already recovering and about to resume work, the other had had intense diarrhoea and had left the work six weeks previously. The diarrhoea had persisted for 4 weeks, and in addition he had lost 3 stones in weight and was extremely weak and breathless. He attended for a full examination including blood tests, barium meal and test meal. An x-ray film of the chest showed an extreme degree of emphysema and he was not considered a fit subject for gastroscopy.

Of the 4 remaining cases off work for reasons of health one was pregnant, two were over 60 years and had bronchitis and emphysema, and one was recovering from a recent attack of pneumonia.

The majority of the people interviewed had had gastro-intestinal symptoms for a variable length of time after leaving the factory. The chief complaint was nausea with disturbance of appetite and an intense dislike of any smell that reminded them of the chemical works. These symptoms had eventually passed off, and apart from the two cases mentioned above and one other individual who said that he had been more chesty since his discharge, no one thought he had suffered any permanent ill-effects. Almost all had returned to full-time work in such strenuous occupations as coal-mining, munitions and aircraft work, a short time after their discharge and had remained in full working capacity. The average time interval since discharge was 10 ± 7 months.

The three cases of albuminuria were identical in that the urine had originally been free of albumin and its presence had been discovered at the routine medical inspections which were held at the factory each month. Though the subjects had experienced gastro-intestinal effects similar to those described in the group as a whole, there had been no other subjective evidence of ill-health. A trace of albumin was still present in the urine of all three but there was no disturbance of the blood chemistry or blood pressure. One man was working full time in another part of the factory, and one woman was doing all her housework and looking after her grandchildren. The other man was less fortunate in that he had developed a compensation neurosis and was rapidly becoming unemployable. He felt he had a financial grudge against the firm and devoted his whole time and energy to getting his insurance company to take legal proceedings. There was nothing on physical examination to suggest that he was not fit to do full-time work.

The only case of enlargement of the liver was discovered on clinical examination by the factory surgeon during a bout of diarrhoea and vomiting following carbon tetrachloride exposure. The man was referred to hospital where the finding was confirmed. There was no jaundice and he made an uninterrupted recovery from the gastro-intestinal disturbances. When seen by us he had been back at full-time work for two months. He looked well and his liver was no longer palpable.

The man with acute pancreatitis was admitted to hospital during a bout of vomiting that had begun three days previously, immediately after exposure to carbon tetrachloride. The vomiting was accompanied by intense abdominal pain. He was regarded as a surgical emergency and operation revealed an intensely congested haemorrhagic pancreas but no fat necrosis. The abdomen was closed without drainage and the patient made an uninterrupted recovery. When seen by us five months later he was back on a light job and felt well except that his appetite was still capricious. Clinical examination was essentially negative.

Discussion

As indicated at the beginning of this paper, the classical effects of carbon tetrachloride poisoning are narcosis, acute hepatic necrosis and acute nephritis. In our survey of over 170 men and women working in heavy contact with carbon tetrachloride only 1 case of enlarged liver and 5 cases of albuminuria were found, and all six recovered without any sign of progressive hepatic or renal disease. On the other hand, more than half the total 170 had been discharged or transferred from their employment on account of symptoms attributed to carbon tetrachloride poisoning. This suggests that in the past attention has been too closely concentrated on the lethal effects of carbon tetrachloride, and disabling symptoms have been neglected or misinterpreted.

Our investigation has shown that the characteristic symptoms of exposure to sublethal concentrations of carbon tetrachloride vapour are gastro-intestinal distress and mental hebetude. The alimentary symptoms are associated with hypertonicity, irregular peristalsis and spasmodic contraction of the stomach and intestines, and with

accelerated passage of the meal. They may be severe enough to simulate an acute abdominal emergency. The mental symptoms are characterized by lethargy and loss of mental agility, a subnarcotic effect. These symptoms are not associated with any physical signs of disease. In particular it may be noted that toxic amblyopia or restriction of the visual fields was not found, despite statements to the contrary (Wirtschafter, 1933).

Elkins (1942) was one of the first to comment on the occurrence of symptoms such as we have described in workers exposed to concentrations of carbon tetrachloride which had hitherto been considered harmless and which had produced little objective evidence of injury. He inclined to the view that they reflected the early stage of liver damage. The clinical picture revealed in our investigations, however, was not at all suggestive of hepatic or renal disease and the laboratory data did not indicate any impairment of function of these organs, in spite of prolonged exposure and the presence of symptoms in some cases for over twelve months. It is true that in a single individual normal liver function tests may not mean a great deal, but we know of no group of proved cases of diffuse disease of the liver in man in which the results of estimation of the serum bilirubin and phosphatase, the plasma proteins and the Takata-ara reaction, have been consistently negative. Further support to the view that the gastro-intestinal symptoms of carbon tetrachloride poisoning can be divorced from liver damage is given by Minot and Cutler's (1929) observation that in dogs given large doses of carbon tetrachloride, symptoms such as vomiting, diarrhoea, weakness and twitching are relieved by the administration of calcium but the damage to the liver is not reduced.

Studies of the effect of carbon tetrachloride on the liver in animals provide an explanation for the great rarity of chronic liver damage in man and suggest the reason why no lesions could be demonstrated in our cases, even though exposure might have been particularly heavy on occasion (Bollman and Mann, 1931; Cameron and Karunaratue, 1936). The changes produced in the liver by multiple administration of carbon tetrachloride depend on the size of the dose and the interval between successive doses. To bring about permanent liver damage there must be exposure sufficient to produce an immediate toxic effect and the dose must be repeated at short intervals. The acute lesion is always a fatty degeneration in the cells of the central and mid-zonal regions of the liver lobules. In the rat, repair of central necrosis is complete in fourteen days, and if the intervals between doses of carbon tetrachloride are spaced beyond this, the drug can be administered indefinitely without producing any alteration in the liver. If each dose of carbon tetrachloride is too small to produce changes in the liver, no matter how frequently it is repeated, there will be no hepatic damage. In rats, even though the toxic dose is repeated often enough to produce extensive fibrous bands round the liver lobules, together with central necrosis and areas of regenerating liver tissue, the process may still be reversible and the liver may revert to normal on discontinuing the drug. After a certain time however, the cirrhotic changes become irreversible.

We must therefore look beyond the liver and the kidneys for an explanation of the mechanism of chronic carbon tetrachloride intoxication. The symptoms bear a strong resemblance to post-anaesthetic sickness and recall the chemical relationship between carbon tetrachloride (CCl_4), chloroform ($CHCl_3$) and ethyl chloride (C_2H_5Cl). It is therefore possible that both the mental hebetude and the gastro-intestinal upset are due to an effect on the central nervous system and are explicable in terms of the narcotic action of carbon tetrachloride. Beattie, Brow and Long (1930) showed that chloroform exerts quite sharply localized effects on the sympathetic centres in the hypothalamus. We have been impressed by the resemblance between carbon tetrachloride intoxication and the gastro-intestinal effects produced by hypothalamic stimulation. Some of the protocols from Cushing's (1932) experiments, in which the hypothalamus was stimulated by the injection of pituitrin and acetyl choline into the lateral venticles, could be applied without alteration to carbon tetrachloride sickness.

"This was accompanied by pylorospasm and antiperistaltic waves leading to three attacks of vomiting. Each attack was accompanied by vigorous antiperistalsis. . . . On the cessation of vomiting the tone of the stomach remained increased with prominent, apparently swollen rugae. In 20 minutes no visible trace of barium remained in the stomach, most of it being in the lower ileum. In one and one-quarter hours the head of the barium column was in the hepatic flexure; no stool till following morning."

It is therefore suggested that mental hebetude is due to the effect of carbon tetrachloride on the cerebral cortex, and the gastro-intestinal symptoms are due to stimulation of the parasympathetic or inhibition of the sympathetic centres in the hypothalamus. Both effects can be paralleled by the known actions of chloroform. The fact that they are not due to hepatic or renal disease does not mean that we can afford to overlook their unpleasant nature and significance. The difference between the concentration of carbon tetrachloride which affects the central nervous system and that which affects the liver and kidneys does not seem to be large. If working conditions are such as to give rise to symptoms of chronic intoxication, the danger of acute lethal effects must be present. For this reason we hesitate to suggest any therapeutic indications for the treatment of chronic carbon tetrachloride poisoning. It is, in fact, the very occurrence and unpleasantness of the symptoms which has made carbon tetrachloride a relatively safe solvent, and to palliate them might be as harmful as taking the smell out of domestic coal-gas.

The emphasis should therefore be placed on better design of plant, better ventilation, better use of masks. Recent experience at the factory under observation suggests that alternation of work, with successive weeks in and out of exposure to carbon tetrachloride, may improve efficiency when conditions of work cannot be made ideal.

Summary

1. A detailed examination has been made of workers at a factory in which exposure to carbon tetrachloride was heavy and persistent owing to wartime difficulties of ventilation.

2. Over a period of two-and-a-half years more than half the workers had been discharged or transferred to other employment on account of symptoms attributed to carbon tetrachloride poisoning.

3. Evidence of hepatic or renal damage was rarely obtained. The characteristic symptoms were mental hebetude and gastro-intestinal upset.

4. Investigation of the gastro-intestinal tract by fractional gastric analysis, radiography and gastroscopy, showed gastric hypersecretion, and hypermotility with accompanying irritability and irregular contraction throughout the alimentary tract.

5. No visual effects were detected.

6. The symptoms cleared up in a few days or weeks after removal from exposure, though some disturbance in the alimentary pattern might remain for some months.

7. It is suggested that both the mental hebetude and the gastro-intestinal upset are due to the action of carbon tetrachloride on the central nervous system.

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THE INVESTIGATION OF TOXIC HAZARDS *

BY

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(Imperial Chemical Industries—Dyestuffs Group)

The purpose of this paper is to draw the attention of medical officers in industry who are responsible for the health of workers engaged in operations involving the use or manufacture of toxic materials, to the importance of a measure of fundamental or elementary knowledge of the measures that must be taken to discover the dangerous properties of such materials.

A high proportion of the work of industrial doctors has to do with matters of organization, routine examination to determine the presence of every-day disease, accident surgery, ventilation, lighting and heating, canteens, transfer to and from particular work, sickness absence and so on. Whilst all such activities can be regarded as scientific activities, there is at least some doubt as to how far the average doctor finds himself in a state of confidence when expressing views on matters somewhat outside the sphere of general doctoring.

We have all in recent months seen publications on so important a matter as sickness absence in which conclusions alleged to be based on statistical analysis serve merely to show that the basal elements of scientific observation are all too little appreciated. It seems to me that industrial medical men must realize that in some fields they must start *ab initio* and not assume that an opinion can be given merely by virtue of the fact that the matter has something to do with health or sickness.

Many of us have been called by the national need into work which demands an approach of a qualitatively different kind from that which obtained in the consulting room or hospital. The view has frequently been voiced, and voiced with conviction, or with superciliousness, that the problems of industrial medicine are well within the scope and competence of any good all-round doctor and that, therefore, the insistence of many of us on the need for special training was so much vapour.

I hope that, in the course of this paper, it may become clear that some measure of training is necessary at least in the study of toxic materials.

I will close this short introduction by laying down a fundamental principle which must always be kept in mind in work of this kind. It is this: 'You never find anything unless you know what you are looking for.'

Those who have still a recollection of the mental processes which go on when one examines a slide of pathological tissue for diagnosis will know what is meant. What happens, roughly speaking, is this: first one tries to recognize the organ or tissue and this is done partly by experienced visual memory and partly by analysis; when this is satisfactorily concluded upon, one then tries to establish the nature of the abnormality by fitting what is seen to visual pictures of known conditions.

The process is one of asking oneself whether such or such appearance is present. In other words, one is looking for something which is already in the mind.

A similar process is gone through in a more reflex manner when a clinical examination of a patient is made. So often an abnormality is detected without the examiner being able to produce a diagnosis, because he is unable to fit his observation to an already known fact, usually a fact of pathology. This sort of thing is particularly evident in examining workers who are engaged in industrial hazards. To examine such subjects with the commendable hope that the disturbances in structure or function will be detected by means of the much advertised clinical sense, is to run the risk of missing most important cases. The situation is difficult enough when one knows what to look for; without such knowledge the likelihood of detecting early clinical changes is very remote. Indeed, this has been the case in the history of the investigation of most industrial hazards. The medical man has had to wait for manifestations of disease, which nobody could miss, before being in a position rightly to attribute them to the relevant agent.

Thus, as it seems to me, the necessity becomes apparent that the medical man must somehow obtain so vivid a picture of the pathological or pathological-physiological properties of the substances he has to deal with that clinical observations can almost at once be properly correlated.

Simple examples will at once suggest themselves. Thus, if a medical officer is not acquainted with the fact that exposure to certain chlorinated hydrocarbons may lead to contraction of the field of vision, it will not in general occur to him to institute routine mapping of the fields, and hence he may miss the early manifestation of toxic changes. A similar situation arises in men exposed to carbon

* From a lecture delivered to the Association of Industrial Medical Officers. October, 1943.

disulphide when a characteristic central scotoma may arise.

Let us consider another substance for a moment. Ethylene chlorohydrin is a simple derivative of ethyl alcohol—monochlor ethyl alcohol. Very little information on the properties of this compound exists in the literature, in fact only one proper paper. Men working on its manufacture in carefully prescribed conditions suffered no apparent harm for years. The advent of war led to a quite different situation, and soon a considerable number of toxic events occurred, including deaths. Here was an excellent example of the helplessness of the medical service; not knowing what to look for, it was not to be expected that the insidious action of this material would be detected at a reasonably early stage.

A vast amount of work has been done on benzol, both physiological and pathological. Clinical records exist of large numbers of cases. In spite of this, medical detection of early cases is still extremely difficult. The old claim that leucopenia was an early index of toxic effects is certainly not true in a sufficient number of cases to make it reliable as a diagnostic test. Abnormalities or bleeding- and clotting-times are probably late effects. The sulphate urine ratio is not sufficiently precise and requires massive absorption. Anaemia is probably a very valuable index, but again it is a somewhat late phenomenon. Here is, then, an instance of a compound on which much more research is still required before the medical supervision will have the proper thing to look for in its hands.

An instance which is topical is that of T.N.T. The determination of the precise period at which the process of liver damage begins is still not possible. The cry for liver function tests has been going on for many years. The precise liver function to be tested out of the innumerable things the liver can do is not known. Studies are in progress. When the crucial index of liver damage is in our hands we shall know what to look for, and perhaps eliminate the incidence of this occupational disease in its fatal forms.

A notable instance comes to my mind, which was investigated most ably by Dr. Donald Hunter and his colleagues. Here the ignorance of the manufacturers was responsible for dire events. The substance to be manufactured was methyl mercury nitrate ($CH_3.Hg.NO_3$). The sequence of events is worth mentioning.

Methyl iodide (a most dangerous compound) was prepared from CH_3OH, P and iodine. This was then allowed to react with Hg under electric lamps, methyl mercuric iodide being formed. The material was broken up by tapping on rubber sheets. This was done in a room 16 feet square, with 4 skylights, 2 windows and a large double door—all open. In the next stage the dry methyl mercuric iodide was mixed with a solution of mercuric nitrate in a power-driven pestel and mortar mill.

The insoluble mercuric iodide was filtered off and an almost saturated solution of methyl mercuric nitrate obtained. This was diluted and mixed with an inert powder, was then dried, ground and packed.

Masks, goggles and elbow gloves were worn: ventilation of the room—40 feet square—was good as far as windows, skylight and gaps in the wall could make it, but it was not good enough.

Twelve men were involved in the work; 8 showed mercury in the urine and 4 did not. There was no doubt that the symptoms of mercury poisoning, which developed in 4 cases, were due to inhalation of dust. With the exception of tremor, the usual symptoms of poisoning by inorganic mercury were absent. The nervous system only was affected. Severe generalized ataxia, dysarthria, gross constriction of the visual fields were present in all cases. Memory and intelligence were unaffected. The cases were difficult to handle and much re-education of movements was required.

Here we have an extremely toxic process, on which men were employed, without the employer *apparently* having any knowledge of the extreme hazard of the product. Hunter's investigations showed that animals exposed to the vapour of the material developed marked lesions in the brain and cord. There was even less excuse than might have been advanced on the ground that the toxic properties of methyl mercury nitrate had not been published, for the toxicity of methyl iodide is very well known.

Another example in a large chemical concern which possessed a considerable medical service is worth a note.

The process involved was the manufacture and distillation of a chlorinated aromatic amine. The compound was of great importance, and it was thought necessary to prepare the base as opposed to the hydrochloride

The operation was undertaken in a hot August. Ventilation was poor and the properties of the material had not been studied from a physiological point of view. In a very short time several of the men had developed an acute haemorrhagic cystitis. I have made a careful study of the compound involved and, as a result, it has been possible to show from purely physiological experiment that, by modifying the molecule, these effects could be prevented. By adapting the process to the modified molecular structure, it has been possible to manufacture the material required during several years without any adverse effects on the men.

One final example of ignorance leading to severe toxic results; this time on the part of a worker who, ignoring works instructions, became severely ill, unfortunately an all too common event in chemical factories. Working with a liquid—o-toluidine—the worker spilled a cubic centimetre or two into his top-boots. Instruction was that in such a case the worker should immediately report, have himself stripped, bathed and await orders. This man ignored all this. A few hours later he felt sick, and on then belatedly reporting he was found to be severely cyanosed. On return home he was later

taken with an acute haemorrhagic cystitis which his doctor was at a loss to understand. He wisely contacted my department, and it was possible for us to deal with the situation, but it took several weeks to get the patient quite better. There have been no sequelae after two years. We mention this case to show that workers must realize the character of hazards as well as managers and doctors.

I hope it will be clear from these examples that some radical attack on the problems of toxic hazards is urgent.

As the years have passed since the institution of a Factory Medical Inspectorate, a great deal of information has been accumulated by the Inspectors on the properties of many materials, but this knowledge has, in the main, been obtained from clinical cases of actual poisoning. Valuable as this has certainly been, we have no excuse nowadays, or at any rate in peace-time, for allowing cases of poisoning to occur if the physiological properties of chemical products can be determined by experiment.

Modern emphasis is on prevention, and I know of no field in industry in which this is more needed and in which more success can be attained.

I proceed, therefore, to certain aspects of the investigation of toxic hazards. These will be elementary, but if pursued will amply repay effort.

There are four ways of discovering the physiological properties of toxic or suspected materials: (a) Literature search; (b) Physical and chemical properties; (c) Experimental study; (d) Clinical investigation.

(a) *Literature Search.* This is obvious, but not all manufacturers have installed adequate facilities for such a search. Nor is such a search to be regarded as something easy. Language facility is essential. Membership of proper libraries is needed.

In addition, a proper filing system for permanent record is required, and additions must be made as knowledge increases.

In the chemical industry, particularly the organic, the choice of such a filing system is no easy matter, but in other industries it is perhaps easier. From the doctor's point of view, he must be in a position to use his accumulated record in such a way that he can quickly and confidently transmit to the operating departments what he knows about the compounds involved.

An example of such a report form is here shown.

TOXICOLOGICAL REPORT

Names of Material.

Ref.
Date

Chemical ..... Formula or Composition .....
Trade ....

A. Physical and Chemical Data. Solid Liquid Gas Dust	Colour..... Odour..... M.P..... B.P..... V.P..... Reaction..... Volatility..... Particle size..... Specific Gravity..... Detection..... Solubilities					
B. Routes of Absorption. Modes of Excretion.						
C. Known effects on man.	Central Nervous System and Special Senses	Respiratory	Cardio-Vascular	Gastro-Intestinal	Urinary	Other Systems
Acute						
Chronic						
D. Toxicological Properties. Animals.	Solid / Liquid } L.D.50..... *Gas.* Toxic concns. with times..... (p.p.m. (v/v) : mins.) ..... *Pathological effects.*					
E. Probable effects in man in industrial conditions.						
F. Recommendations, Prevention and Safety.	Plant ..... Max. allowable concn. (gas or vapour) ..... Protective appliances ..... Medical Supervision					
G. Treatment of Poisoning. Contra-indications.						

FIG. 1.

By filling up such a report form, the doctor or any other person will immediately be in a position to see what is known and what is still required to be known.

It is clear that literature search alone is very often not sufficient. Text-books are rarely of great help, perhaps because there is no space to deal adequately with all subjects. The I.L.O. publication 'Occupation and Health' is often useful but badly requires bringing up to date. Published papers must in the last resort (or perhaps the first) be the source of information and the medical officer must often build up his own literature survey.

(b) The second method of understanding the nature of the physiological action of toxic or suspected materials is to find out oneself: the first requisite being a thorough appreciation of the *physical and chemical properties* of the material in question to the extent that these may influence the entry into the organism and the toxic effect on the latter.

Let us, first of all, consider what in general we want to know.

The decisive points must have relation to the manner in which, so far as can be foretold, the worker is likely to be exposed to the material in question. Thus, it might be said in almost every industrial problem of this kind that the worker is not asked to eat the stuff. But it cannot be assumed that, in fact, he won't ingest it.

We are all acquainted with the predatory activities of workers when faced with the bottle labelled 'Alcohol.' A case comes to mind in which a worker took home a quantity of sodium nitrite which he though was salt: the result of using this in cooking was to kill the whole family. Another case was that of a man who, having an urge to shuffle off his mortal coil, took home a quantity of sodium cyanide from a works, retired to the cellar and ended his life.

Then we have the recorded cases of men who have drunk deeply of organic solvents.

Apart from voluntary ingestion of dangerous materials, we have the involuntary. This sort of event is not, in general, a very serious matter, but in certain industries it becomes a matter of first importance to forbid eating or chewing on the plant, and in a good many cases, nail-biters must be eliminated.

These points are mentioned because the determination of toxicity of substances given by mouth should not be regarded as of academic interest only.

It is clear that the nature of the material will determine in great measure the manner in which the organism is likely to meet it, and the route by which it is likely to be absorbed.

When reference is made to the 'nature of the material' under consideration, the least that this can mean is its chemical identity. Theoretically this should always be available, or at any rate determinable. In practice we know that very frequently the employer himself does not know what he is using. Products are used for a multitude of purposes under bizarre and meaningless names, which are no clue to their compositions and which indeed may obscure them. It is the particular industrially important property which is emphasized and not the composition. Nowhere is this more blatant than in the case of solvents. Time and time again cases have been reported of toxic effects attributed to exposure to volatile solvents in which the offending substance was either not known to be present or from which it was specifically stated that certain toxic solvents were absent.

The 'nature of the material' must also include a statement of the degree of purity and the nature of the impurities, for the use of completely pure chemical individuals in technical processes is unusual. It will be appreciated that the physical properties determine the readiness with which the material can enter the organism.

A few simple examples may serve to indicate that the appreciation of physical properties is of great importance.

Metallic mercury has a high boiling point, and hence *a priori* it might be considered likely that in operations far below the boiling point the hazard to workers would be minimal. That this is not the case is known to all.

Cases of mercurial tremor among laboratory boys and physicists have occurred, whose contact with mercury was simply that arising from bench work. Mercury strewn in droplets on the surface of a laboratory bench volatilizes and is absorbed by the operators through the respiratory tract.

Again lead, which is used in industry in a multitude of forms, can be absorbed into the organism in the form of most insoluble salts or oxides. Lead chromate, oxides, sulphate, all practically insoluble in water, might be held to offer little chance of toxic effects, but we know perfectly well that inhaled as fine dust the organism is able to transform them into readily diffusible forms.

In the filling factories, the physical property possessed by both T.N.T. and tetryl of being soluble in lipoids lies behind the whole theory of poisoning by absorption through the skin. But care must be exercised here lest one overlooks the dust and fume hazard by over-concentrating on the skin absorption.

In general, liquids which are lipoid solvents require careful assessment, for it is easy for the uninitiated to raise alarms where none is warranted. Thus, a perusal of the experimental results with dichloro-ethane (ethylene dichloride) might lead one to expect many industrial casualties. Actually, precaution is such that none has, as far as I know, been reported, although symptoms due to narcotic effects may occur.

The precautions laid down for the handling of trichloro-ethylene are well known to all those engaged in de-greasing machinery. This compound possesses in an outstanding degree many physical properties necessary for good anaesthetic action and, indeed, has recently found considerable favour among anaesthetists. But its virtues as an anaes-

thetic render it all the more necessary to treat it with caution. Chronic effects attributed to this solvent still await explanation, although its gross acute toxicity appears to be not serious.

In the vast field of organic compounds, there is a tendency to ignore purely physical properties, particularly when dealing with solids. I always look with suspicion at materials of low melting point and high or considerable lipoid solubility if in association with toxic radicles. These are the compounds which more or less readily penetrate the skin. In general, these compounds show little, if any, solubility in water.

The importance of careful control of temperature in certain porcesses is illustrated by the cases of toxic effects arising from the handling of chlorinated naphthalenes—synthetic waxes largely used in insulation work. The process is simple, the danger lies in not realizing or ignoring straightforward instruction. The wax melts at a certain range of temperatures, and it is required that the material should be kept molten, but not raised above a certain maximum range. When this is not done, the material gives off vapour and this vapour is both irritant to the skin and poisonous to the liver. 'Chloracne' cases have been described and liver atrophy and necrosis has occurred too frequently. The cold solid wax on the dipped articles leads to no troubles, but inhalation of toxic dust may follow processing of the articles. This is a good example of the significance of physical form and properties.

Difficulties which may be met with as to workable temperatures or as to the evolution of fume at prescribed temperatures should not be taken with indifference. Satisfaction must be demanded or the process stopped.

I think it was in a shed where this sort of process was going on that a certain medical officer, who deserves great commendation, decided that conditions were dangerous. Receiving no satisfaction from his management, he printed a notice—*This Plant is Dangerous*, affixed it to the door and cleared all the workers out.

One final example of the importance of temperature. In the rubber industry, it is often necessary to incorporate a compound which when heated liberates an inert gas. This gas enmeshed in the rubber mass creates the condition of *sponging*. The final product when cold has no irritant properties and is handled daily with impunity. But when it is hot or warm, application to the skin leads to severe dermatitis and absorption through the skin may take place and lead to cyanosis.

Another physical property of great importance is *density*, especially when dealing with a gas or vapour. In war-time plant which may have been erected in a hurry, the result may sometimes be that units of plant are rather crammed together and ventilation is unable to cope with local pockets of air. Gases or vapours greater in density than air tend to collect in such pockets. It then becomes necessary to introduce local draught, but evidence will always be sought by managements as to any higher concentration at these points than in the general air space in the shed; and the doctor is well advised not to start talking before he has the data in his hands.

I have considered it desirable to multiply examples because I am by no means convinced that medical officers as yet realize the need for inquiring most meticulously into the physical properties of materials before examining the more medical aspects of toxic materials.

The *chemical properties* of industrial materials are of importance to us, in so far as they may influence the views of medical officers and the kind of advice which they will be led to give to the managements.

I take it that a safe, rough definition of a chemical property is that it is a power latent in an element or compound which permits it, in suitable conditions, to interact with other elements or compounds in a way which results in a change in the interacting materials other than change of state or aggregation.

From the point of view of the industrial toxicologist, it is evident that merely to apprehend the chemical properties of the interacting materials may be quite insufficient. He must recognize that the products of the interaction or the by-products may constitute the important feature for the investigator of hazards.

Thus, in the manufacture of certain complex dyestuffs of the sulphur colour class the initial materials used, whilst not entirely without toxic properties, are relatively easily handled with safety. But as a result of the reaction H_2S is liberated and constitutes the principal hazard.

Similarly, one may have residual materials after a reaction is completed which are potentially or actually dangerous products.

Of a potential hazard I shall give one notable example. In a process where the residual fluids contained inorganic sulphides, the run-off was into a sort of gutter. This gutter was also used by another unit for running off waste acid, but an arrangement had been made whereby the two run-offs were never run together or before water or alkali had cleared all remnants of the last run-off away. On one unfortunate occasion a misunderstanding arose and the acid met the sulphide. The result was a tremendous evolution of H_2S and a worker—a woman—collapsed and was trapped in an inaccessible spot. After extrication with great difficulty she was brought round sufficiently, in the ambulance room, to permit of her transfer to hospital. Here she had respiratory symptoms and great restlessness, both common in H_2S poisoning, and unfortunately she died within a few hours.

Now it cannot be expected by industry that the medical officer should be a chemist, but it is perfectly justifiable to expect him to know in detail the various stages of the processes and to be in a position to ask the questions which are relevant to his understanding of the hazards.

One aspect of this question of chemical properties deserves special mention. It is so often the case that information is required at short notice on the

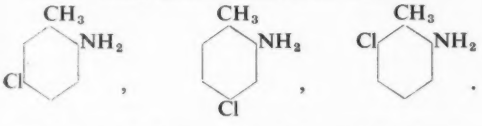
hazards of a material that the medical man, failing relevant literature, may have to make a guess. Although it is always possible to make a guess on the safe side, one looks a little foolish if later information reveals that his guessed apprehensions were so much warmed air. We call this sort of guess toxicity by analogy, but in order to do it in the organic field with some degree of verisimilitude it is necessary to comprehend the significance of structural formulae.

The correlation of chemical structure with pharmacological or toxic action has never been attained except in isolated cases. I think we should all agree that there is no obvious reason for quinine to be so potent against the plasmodium or for Bayer 205 against the trypanosome. Some advance is being made on the lines of the action of sulphonanilamide in competing for p-aminobenzoic acid against the demands of the haemolytic streptococcus.

But in general, in the field of toxicology, we must rely on *ab initio* investigation or on experience, taking into account all the physical and chemical properties which appear relevant.

The specificity of toxic effects in relation to chemical structure is sometimes striking. This is a vast subject in itself, but I will choose two examples.

The following three substances are isomeric:



The first of these produces in certain circumstances rapid and violent haemorrhagic cystitis, both experimentally and clinically; the others do not.

The following two compounds are also isomeric:

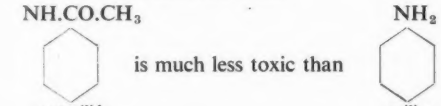
$CH_3—O—NO$ and $CH_3.NO_2\left(CH_3.N\begin{matrix}O\\O\end{matrix}\right)$

methyl nitrite — B.P. −12°C.

nitro-methane — B.P. 101° C.

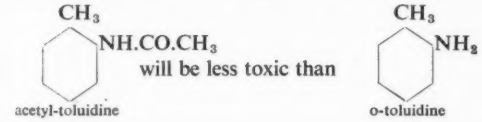
All are familiar with the depressor activity of nitrites, but the nitro-paraffins do not act in a similar way.

Guessing in cases such as these is dangerous. But from our knowledge that



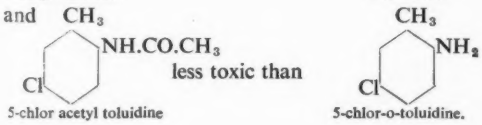
acetanilide — is much less toxic than — aniline

we can reasonably offer the guess that



acetyl-toluidine — will be less toxic than — o-toluidine

and



5-chlor acetyl toluidine — less toxic than — 5-chlor-o-toluidine.

The important chemical properties of *reduction* and *oxidation* should always be kept in mind.

Whereas the organism has mechanisms for buffering extraordinarily large amounts of acid and alkali, it is less endowed for dealing with reducing and oxidizing compounds. It is true that considerable concentrations of reducing agents exist in the blood, but these are not in a position to exert this property because the reaction conditions are not suitable.

The absorption into the circulation of oxidizing and reducing agents, which can exert these properties at the reaction of blood, will exert profound effects on the blood pigment and lead to all the consequences of interference with the oxygen-carrying capacity of haemoglobin.

Powerful oxidizing and reducing agents exert a deleterious action on the skin, a fact which should always influence the medical officer in criticizing the well-known agents used for skin cleansing.

On the importance of the *acidity* or *alkalinity* of compounds in aqueous solution all will be informed, but special mention must be made of two materials which require the utmost attention at all times: *ammonia* and *lime*. These compounds have most devastating effects if they enter the eye. Ammonia liquid in the eye, after what has appeared to be adequate irrigation and relief of symptoms, can continue to exert a steady effect leading to clouding of the cornea, penetration into the anterior chamber and disintegration of the lens.

In the case of lime it is usual to attempt neutralization of the caustic effect by irrigation with ammonium chloride or tartrate. Some ammonia is formed, but is soon swept away and the calcium is solubilized. The occurrence of such cases indicates lax safety supervision. Quicklime must never be handled without goggles. The lime burn in the eye often leads to an angry, resistant granular conjunctivitis, with a tendency to burrow under the bulb and may produce a permanent ectropion.

In both these cases the utmost speed of action is essential so that appropriate apparatus is required wherever the hazards exist.

In considering the chemical properties of a material, it is well to keep in mind its possible action on some essential constituent in the organism. A simple example is, say, oxalic acid. Apart from being an irritant poison it kills by removing ionized calcium from the blood, if absorbed.

Similarly the relation of fluorine and hydrofluoric acid to calcium will come to mind as also the use of injection locally of calcium gluconate in cases of hydrofluoric acid burns. The relevance of remembering decomposition products of compounds is shown in the case of phosgene, the effect of which is almost certainly related to the liberation of active HCl.

The use of oxygen and of oxygen-carbon dioxide mixtures is known to all as perhaps our most valuable stimuli to the cardiac and respiratory systems, but in some cases the value of oxygen is based upon the chemical properties of the toxic material which

led to its use. Carbon monoxide springs to the mind. Here by increasing the oxygen tension in the blood the reaction Hb+CO→Hb.CO is more readily reversed and the CO removed.

Let us examine the case of methaemoglobinaemia. Here the iron in some of the blood pigment is in the oxidized ferric state and cannot carry oxygen. The use of O_2 or O_2—CO_2 is here dictated by the need to assure a maximum saturation of such haemoglobin as is still functional until such time as a more normal concentration of Hb is reached. The use in such cases of intravenous methylene blue is based upon its property of being a powerful hydrogen acceptor. Thus, in the tissues a favourable condition is produced for the liberation of intramolecular oxygen for the support of tissues deprived of normal oxygen supply by the abnormal state of the blood pigment. The application of methylene blue in cyanide poisoning has the same background since cyanide inhibits tissue oxidation.

The property of protein precipitation possessed by such agents as tannic acid, tri-chloracetic acid, picric acid, etc., lies behind their use as agents in the treatment of burns.

The deposition of lead in the bony skeleton depends on the possibility of a double decomposition of calcium phosphates and lead compounds.

The formation of the silicotic nodule possibly depends upon the slow formation of silicic acid at points of deposition of silica particles.

These are all elementary points serving to show that a proper assessment of chemical properties is necessary to the medical officer who aims to visualize his hazards as they act and to understand the rationale of his therapeutic measures.

(c) *Experimental Studies.* With all the efforts the doctor may make to establish the toxic properties of his materials, the time must come when he is faced with substances about which little or nothing is known from the toxicological point of view or about which he feels that extant information is unsatisfactory.

In such event, apart from the precarious guess method, he has no alternative except *experimental* and/or *clinical investigation.*

Experimental investigation involves laboratory studies on *animals.*

Now it is customary to cast a somewhat dubious eye at animal work in this and other fields and, indeed, one may perhaps ascribe to this attitude the rapid disappearance of animal experiment or demonstration after the second year or so of medical studies. This is a pity, for it is by animal experiment that we can develop a grasp of process as opposed to established change in tissues. The object of medical investigation is far more to obtain knowledge on the process of attack on and change in the cell than merely to describe the terminal state in which the cell finds itself. The need for this state of mind will be at once apparent in such a field as cancer investigation. Of course, the appropriate techniques have to be developed and therein most often lie the difficulties.

Animal experiment can give a great deal of information, but its application to the human subject requires considerable care and experience. The quantitative aspect can be fairly accurate in animal work, but indiscriminate acceptance of animal figures for human subjects would be, in many cases, unjustified.

We have further to remember that, if it were possible to carry out experiments on men, we should still be faced with the factor of *individual variation* which would prevent a universal application of results to all subjects. We all know of cases that can take aspirin or quinine and others who cannot. Similarly we have individual variation to skin hazards and even gases. And this individual variation is not, in general, referable to manifest structural signs. An apparently completely uniform population of animals shows marked individual variations even in the most carefully controlled conditions. The term *toxic dose* of any material thus requires careful consideration, for whilst a given dose may be toxic or lethal to a certain proportion of a given group of animals of a particular species, it will not necessarily be so to all.

We reserve for a later contribution the consideration of aspects of the experimental determination of toxicity and the interpretation to be applied in industrial problems.

Reference has been made to individual variation within any given species, but variation as between species may be even greater. Hence the application of such findings to man is always a matter only of suggestive inference. In pharmacological studies determination of M.L.D. (i.e. median lethal dose =dose which in the long run will kill 50 per cent. of animals) is always a necessary preliminary to utilization of drugs in human subjects. But one has to be prepared for adverse findings in man. A topical example will perhaps be of interest.

In research to develop new compounds of the sulphonamide type, a compound was prepared which, as far as animals were concerned, possessed admirably the properties required: it had powerful bacteriostatic activity, a low toxicity, did not produce cyanosis and so on. But on application in the ward in therapeutic doses, the degree of cyanosis produced in man was so great that the substance had to be abandoned. Clearly there was some difference between the power to detoxicate this compound in the rodent and in man.

An industrial hazard with which wrong conclusions might have been drawn is aniline. If the toxicity of this amine had first been studied in the rabbit, a quite false conclusion would have been reached. For whereas aniline produces severe and even fatal cyanosis in man, I have never been able to obtain cyanosis in the rabbit. On the other hand, the rat or mouse or cat or dog would have put one on the right path.

Let us take an example where the sensitivity of the animal is so great that its reaction is used as a most valuable index of impending danger. The case of carbon monoxide is outstanding. Mice

exposed to a concentration of some 500 parts per million $\left(\frac{v}{v}\right)$ for 20 minutes will react with unmistakeable toxic effects, whereas men can support this concentration for at least an hour without trouble. But one does not risk this. If the mouse shows symptoms, the working place is cleared.

But the mouse or canary are by no means infallible in detecting hazardous concentrations of all toxic gases.

These are simple examples. Much greater difficulties of decision are the daily lot of the doctor in the chemical industry.

An example: For certain complicated processes cyanuric chloride $(CNCl)_3$—a solid—must be used. Now the toxicity of this material is very high—5 mg./kg. for mice when injected or given by mouth—and one becomes anxious. But the circumstances in which the compound appears in the processes render it most unlikely to be absorbed by the worker. On the other hand, a compound like crotonaldehyde cyanhydrin—a liquid with a pungent vapour—cannot be used without some degree of transference into different vessels with escape of vapour, and hence its very high toxicity, easily demonstrable on animals, renders it a hazard of great importance.

Thus toxicity in the industrial sense *must have relation to the circumstances of manufacture or use.* Hence the significance of the doctor's knowledge of plant and process. It is this aspect of industrial medicine on which so much emphasis must be laid if its value to industry is to be established.

The intimate knowledge of plant required by the doctor if he is to pronounce with confidence is such that it becomes necessary for him actually to work in the shed with the worker. This is realized in some American factories where the young, or even not so young, doctor spends several months actually as a worker, doing day and shift work and thus learning not only the nature of chemical plant and process but also the worker's terminology.

Every industry has its own ' argot ' and the doctor should know it.

Moreover, the experienced worker has a knowledge which, if properly tapped, will open the eyes of the doctor to many things not to be found either in text-books or in the literature. Toxicity data in application must have relation to the *habits of workers.* It must always be kept in mind that the factory life of a worker becomes after some time a psychological and physical conditioning to external requirements. The result is a more or less uniform pattern of behaviour, and this must be apprehended and understood by the doctor. Recommendations based entirely on laboratory findings as to toxicity without regard to such patterns of workers' behaviour are of little practical value. For, to implement recommendations designed to prevent toxic events requires the understanding collaboration of the worker. If all processes could be carried out in totally enclosed plant, such collaboration might be unnecessary, but such an ideal is never likely to be attained except in a minority of processes.

An example is worth quoting.

You will all know that satisfactory germination in 100 per cent. of seeds is not possible in most soils unless measures are taken to protect the seed against certain fungi. Among such protective agents is a group or organic mercurial compounds. The early experience in the manufacture of one of these was such that it became clear that only if total enclosure were practised could reasonable security of the workers be assured. This compound attacks the skin with production of a bullous dermatitis. In the present process, there is absolute enclosure from the time of mixture of the primary reactants until the automatic delivery of the final product into the receiving tins. So satisfactory is now the process of manufacture that cases are not met on the plant, but practically only in the dressing of the seed by the seed-dresser and in the sowing by the farmer. Proper precaution by the former should in general obviate trouble and, in the latter case, it is only in cases of exceptional sensitivity that trouble arises.

This is the more striking when we consider that the seed is dressed with a diluted product containing only from 1 to 1·5 per cent. of calculated Hg.

I recently saw some cases of distressing character in a farming area, which are worth mentioning. A young farmer had developed an erythematous-vesicular rash as a result of handling dressed seed without proper precaution; he visited his doctor who diagnosed scabies as the condition was certainly very itchy. The patient was plunged into hot baths and scrubbed and inuncted with sulphur ointment. The result was a fearsome mess. When I saw the case, it was one of a generalized, oozing sulphur dermatitis, chronic and intractable.

The fault here lay partly with the farmer, mainly with the doctor, but also in part with the manufacturer who had not sufficiently disseminated knowledge on this particular hazard. Properly treated, the condition can be completely cured even in severe cases in less than three weeks or a month.

But the intelligent co-operation of the worker is essential both in prevention and in treatment.

The example just quoted—it was one of three of varying severity—illustrates another aspect of the responsibility of the doctor engaged in the chemical industry, viz. *responsibility to the user of chemical products.* He must not only prescribe for the protection of his workers in the factory where the product is manufactured, but also be prepared to inform users of its actual or potential dangers and how best to circumvent or neutralize them. No amount of academic knowledge will overcome the problems involved. Such knowledge must be combined with an appreciation of working conditions and the circumstances of exposure. Untoward events may occur which demand an immediate response from the medical officer as to the hazards of the products of his industry. Two mild examples in the dyestuffs industry are of interest.

The first was a trivial event, but led to great anxiety. A child in a Midland town was left alone

at home and proceeded to eat a tablet or bag of the housewife's material known as Dolly Blue or some such name. I surmise that the child looked a pretty sight when mother returned. The alarm was rung, but the dyestuff involved is very soluble and rapidly excreted. Simple diuretics were advised and a mild purge, and in a day or two all appeared to be well.

The second is an amusing case. A certain small dyeing concern operates in an agricultural region and was in the habit of liberating not inconsiderable effluents into a small stream at which the local cows could drink. The principal dyestuff these people used is a black. Now a black dye may contain much beside black compounds. The local authorities raised considerable objections to this. The M.L.D. of the material was found to be so high as to be negligible, but it was clearly also necessary to find how the dye was excreted. So metabolism experiments were set up and on collecting the urine of animals treated with the dye, it was found that a red dye was excreted. Study of this dye in the urine led to its identification as one of the shading materials in the original mixture. Now whilst it could be concluded that the cows would not suffer grievous harm from taking a drink of this unattractive cock-tail, it was by no means certain that the milk would not be of a somewhat revolutionary colour if sufficient of the stuff were taken. So the practice was condemned and the firm had to make suitable alternative arrangements.

In the days when the Channel Islands were in a non-infected state, we received great quantities of tomatoes from them and certain grades of tomatoes were made into tomato puree. Now, as in the case of browned kippers, this country will not eat the product unless it is dyed a nice juicy colour. The dye used is harmless and is added in small amounts. But there must be an assurance that the colour will be maintained in the can almost indefinitely.

A very large quantity was thus prepared during a period some years ago and canned. When some time later a few cans were opened by customers who had bought them at a grocer's, they discovered with alarm that the puree was a jaundiced mess instead of a juicy red. The canners demanded a very heavy indemnity for what was going to be a total loss. Arguments of various kinds were used on both sides, and it was alleged that there was something wrong with the dye which was now probably a dangerous poison.

Now clearly there were three main factors—the dye, the tomatoes and the can.

It was easily demonstrated that the dye was the same as had always been used, the tomatoes could be assumed as the same, so the trouble must have been in the can. The can was tinned iron and it was easy to show that iron reduced the dye to a yellow derivative.

An agreement was reached, since it could still be claimed that the dyestuff makers had not informed the user as to the effects of ferrous metals on the colour.

These examples will perhaps serve to show you that there are aspects of the work of an industrial doctor engaged with toxicological matters which can exercise the mind in manners not usually associated with doctoring. It is not to be supposed that industrial doctoring in general entails work of this kind. But it is in the highest degree desirable that more people should be engaged in it as a constant guard against calamities which occur as a result of ignorance, neglect and indifference in the handling of industrial materials, many, very many, of which exert toxic effects.

The Skin

No discussion of industrial hazards can overlook reference to the skin. As an industrial route of entry of toxic products into the organism, the skin is second only to the lungs, Reference has been made to the rough general criteria of skin absorbability—viz. low melting point, lipoid solubility or miscibility, fat solvents.

But it is not only the properties of the material which determine ease of skin absorption. The condition of the skin itself is a determining factor—hot, greasy, perspiring, for example. Experience, often after notable toxic events, has taught us in the past that certain materials are absorbed through the skin, e.g. aniline, nitrobenzene, toluidine, lead tetraethyl, mercury, carbon disulphide, etc.

To determine of a new material whether it is likely to be absorbed in this way, the physical properties are a very useful guide. But the demonstration on the animal is always desirable, particularly if the material is toxic.

The experimental pathology of the dermatologist is only exceptionally carried out on animals. The reasons for this are obvious. But in the matter of absorption, provided a dehaired area of skin is used, reasonable conclusions can be drawn. There are technical difficulties as, e.g. prevention of licking both by the individual animals and by others, the maintenance of the part exposed without exposing to absorption by the respiratory tract, prevention of removal of material and so on.

It will be convenient to use my reference to the skin to introduce some notions on the importance of a competent knowledge of pathology—both clinical and experimental—in this kind of work.

Let us for a moment consider the place of pathology in general medicine. I think it true to say that it is the science of topographical and histological description of morbid processes. Experimental pathology attempts to relate causes to the findings of topography and histology.

Now it seems to me that, if man is to intervene successfully in the process of disease, some way must be found to eliminate causes or, if that is not attainable at any stage, to get between the cause and the establishment of the morbid changes. The implication is simply that we must not wait for post-mortem material to establish a pathology. It is, in my submission, a most depressing business to wade through the immense contributions of the German

schools of morbid anatomy and to realize how little has emerged which helps us to attack morbid process at a hopeful stage or with hopeful methods.

In the field of work under discussion, immediate causes are in greater or lesser measure determinable and, as has been pointed out, it is theoretically possible completely to eliminate industrial poisoning and disease. As long, however, as man must use his hands to work so long will we have industrial skin disease. And as long as processes cannot all be completely enclosed or otherwise made safe when toxic materials are used, so long will we have poisoning and disease in industry.

When, therefore, the doctor considers the hazards of his industry, he must be in a position to visualize what is going on in and on his workers during their exposure to the toxic materials.

To obtain this view animal experiment in the first place is a *sine qua non*, and complete physiological and pathological study a necessary preliminary to establishing the needed control over the health of the workers.

As to physiology, the effects on respiration, circulation, nerve transmission, isolated tissues, secretions, reflexes should be studied. The metabolism of the material, i.e. the changes it undergoes in the organism and the retention in the tissues, must be dealt with. In certain cases, the absorption of the material can be gauged by the degree of excretion in the urine (and faeces in some cases), and methods must be devised to determine the excreted products quantitatively. In other cases, studies must be made of the effects on the blood and blood-forming organs, on the composition of the urine, on the pigments of the blood, on the digestive processes and so on.

These things must be done both as acute and chronic experiments.

On the pathological side, sections of organs must be prepared to find changes in structure, both from minute exposure and massive exposure for short and long periods. Correlations with physiological findings have to be made so that as far as may be one can visualize what is going on and obtain an indication of the point of necessary intervention when dealing with the workman himself.

The effects of a host of materials on the skin present a most difficult problem.

Of the direct attackers of the skin little need be said; strong acids and alkalies, halogen derivatives of sulphur, organic sulphates, certain organic arsenicals, certain chlorinated hydrocarbons, etc., require little investigation relatively. It is when we come to those substances to which some people are sensitive, or which set up a sensitivity, that considerable difficulty arises in experimental study The usual laboratory animals possess skin which is different structurally and functionally from human skin, and hence response to industrial dermatitic agents is different.

Still, it is possible in a sufficient number of cases to establish what corresponds to dermatitis on animal skin—rabbit, mouse, rat, guinea-pig, horse and pig are probably better animals to use, but not easy to do so.

Much has been written on the patch test.

The application of this test in industry is, in my view, impracticable and in general not justifiable.

In hospital or at a skin clinic, this sort of test to determine sensitivity to a specific agent is possible, but in a factory it is a most delicate matter and if undertaken must have the written acquiescence of the worker subject—otherwise unending trouble may arise.

Taken all in all, we must rely on clues from animal work and, where these are not very satisfactory, on analogy and observation in the factory.

Since the acute reactions of human skin to industrial dermatitic agents are very similar to those in cases of eczema of which the gross pathology is known, it is possible for the medical officer to draw conclusions at a very early stage, provided the cases are made to report at the onset.

But there are many reactions to dermatitic agents other than the ezcematous, e.g. acneiform, bullous, urticarial, pure oedema of a massive character, etc.

And extremely frequently there occurs simultaneously with the skin condition, or sometimes preceding it, a marked oedema of the lids and sometimes a conjunctivitis with persistent lachrymation.

(d) *Clinical Study of Industrial Hazards.* I think it will be wise to state at once that the possibility of clinical study of workers by the factory doctor was, until relatively recently, overshadowed by the business of compensation. It was natural for the workman to look askance at a doctor appointed by an employer, since it appeared to him that such an appointment could only be in the interest of the employer and hence likely to operate against the worker's interests. It is probable that in a good many instances there was justification for this view, but things have changed in recent years. As a consequence, clinical examinations to detect signs or symptoms of industrial poisoning have become easier to institute. It is difficult except in those cases where examination is required by law, e.g. for lead, phosphorus and so on. But there are many materials which demand that regular examinations should be done to detect early signs of disease which are not formally scheduled under Act of Parliament. And, further, it has got to be remembered that to examine a man's blood or urine, say once a month, is a procedure which produces considerable anxiety in his mind and perhaps even more in the mind of his wife.

Explanation by the doctor of the need for repeated examination is likely to produce quite wrong conceptions in a man's mind and even if right ideas are implanted the reaction will often be—'If the stuff is dangerous I want more money': this may be a justifiable position to take up, but since more money will not help the doctor in his control of the hazard, it is not of much value from the present point of view.

It will thus be seen that much tact and understanding of the worker is called for. In order not

to produce a scare in a particular department or plant, it is essential very often to spread the examinations over a number of sections and thus, willy nilly, one collects control data.

The psychological situation as between a doctor and patient who consults him is quite different from that between an industrial doctor and a worker who feels quite well and has not consulted him. Where objective observations can be made, it is relatively uncomplicated, but so much depends on the accurate presentation of subjective symptoms, which the workman may be and often is disinclined to divulge if they appear minor.

A plant was recently inspected where many of the workers quietly left the shed, went round the back and had a quiet and private vomit several times a week and never volunteered the information or even made complaint. Many other instances in various trades could be given.

It has always to be kept in mind that very few substances limit their action to single organs or systems, e.g.—

General Systemic Poisoning. Pb, As, CH_3OH, CS_2.

Circulatory Poisons. $C_6H_5NH_2$, As, $C_6H_4(NO_2)_2$, Pb, Hg, Va, C_6H_6, T.N.T., $C_6H_5NO_2$, CO.

Respiratory Poisons. Si, NH_3, nitrogen oxides, Cl, SO_2, H_2S, cobalt arsenide.

Gastro-Intestinal Poisons. Zn, Pb, As, Hg, Cd, Sb, C_6H_6, cyanide, nitro and amido bodies, tetrachlorethane.

Dermatitic Agents. X-rays, actinic rays, HCHO, tar, benzene, cutting oils, $ZnCl_2$, hexamine, p-phenylene diamine, chromates, petroleum oils, etc.

Action on Skeleton and Joints. Pb, P, acids, As, Hg, mesothorium.

Action on Organs of Special Sense. CH_3OH, actinic rays, intense light, Pb, As, HCN, H_2S, CS_2, Hg, turpentine, Mn, C_6H_6.

Action on Genito-Urinary System. Aniline, benzene, Pb, As, Hg, x-ray, Va, turpentine, b-naphthylamine, phenol, nitroglycerine, ether, p-nitroaniline.

Action on Brain and Nervous System. Pb, Mn, As, CS_2, ether, phenol, cyanide, CH_3OH, trichloroethylene, nitroglycerine, some chlorinated hydrocarbons.

The organization and systematic record of examination of workers are no easy matters and require the most careful study in every case.

Record cards are also required for routine examinations of units of plant: the use of such cards depends entirely on the doctor knowing where and how to look for trouble.

HEATING AND VENTILATION:
REQUIREMENTS AND METHODS

BY

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I. Introduction

'Mental anxiety may, perhaps, be considered the most powerful enemy to the duration of human life, and, next to it, defective nutriment, whether in quantity or quality. But after these, no other cause, at least in modern times, appears to have inflicted so great an amount of evil upon the human race as defective Ventilation. . . .' Thus wrote Dr. D. Boswell Reid in the preface to his 'Illustrations of Theory and Practice of Ventilation.' Reid's book was published just one hundred years ago, but to-day many would still subscribe to his estimate of the great hygienic importance of ventilation.

Ventilation was defined by Reid as connoting the due appropriate supply of air to any apartment. He was mainly concerned with the quantities of fresh air that were necessary, and with the methods by which that air could be supplied; but he had much to say about the chemical and physical properties of the air. He emphasized the need for maintaining adequate warmth, and made pertinent observations concerning the importance of taking air movement into account. Many of the principles clearly enunciated by Reid have been verified or rediscovered by experimenters during the past thirty years. Ventilation is an important branch of industrial hygiene, and it is fitting that in this first year of publication of a new Journal devoted to industrial medicine, which also marks the centenary of the publication of Reid's classic work, tribute should be paid to that great pioneer of the science of ventilation.

As Reid remarked: 'Ventilation need not be expected where food, fuel, and clothing are deficient. Heat is still more essential to the human frame than fresh air. . . .' Man can tolerate an impure atmosphere for long periods, but prolonged exposure to extremes of temperature is likely to lead to acute ill-effects.

The amount of fresh air that can be endured indoors during cold weather is dependent on the adequacy of the heating installation. If insufficient provision is made for warming a building ventilation will be restricted during cold weather. In designing a heating system, the engineer must take into account the amount of fresh air that is to be admitted. Heating and ventilation are indissolubly connected, and they must always be considered together.

Legal Requirements

At the end of the 18th century, Dr. Percival and his colleagues of the Manchester Board of Health found that those who worked in cotton factories were peculiarly disposed to be affected by fevers, and that even where no particular diseases prevailed, those employed in the factories had their constitutions undermined by the close confinement in hot and impure atmospheres. They found also that in well-regulated factories those evils could be in a considerable degree avoided, and they pressed for legislation for the regulation of factories. Following this agitation, the Health and Morals of Apprentices Act, 1802, provided that cotton mills where poor law apprentices were employed should at all times be properly ventilated. That extension of the poor law marked the beginning of factory legislation. Since that time various statutes have contained provisions relating to ventilation and heating.

(i) **Factories**. The Factories Act, 1937, contains a number of provisions relating to ventilation and heating. In all new workrooms a minimum of 400 cubic feet of air space must be allowed for each person; no space more than 14 feet in height is to be taken into account, so that the minimum floor area per person is nearly 29 square feet. A gallery is deemed a separate room.

Effective and suitable provision must be made for securing and maintaining by the circulation of fresh air in each workroom the adequate ventilation of the room, and for rendering harmless, so far as practicable, all fumes, dust and other impurities that may be injurious to health generated in the course of any process. Standards of adequate ventilation may be prescribed by the Secretary of State. The insertion of the phrase requiring the *circulation* of fresh air seems to be a recognition of the importance of air movement in ventilation.

There must be effective provision for maintaining

a reasonable temperature, and no method of heating may be employed which results in the escape into the air of the workroom of injurious or offensive fumes. For sedentary work a minimum temperature is prescribed. The Act states that where a substantial proportion of the work is done sitting and does not involve serious physical effort, a temperature of less than 60° F. after the first hour of work shall not be deemed a reasonable temperature. In each workroom to which this provision applies a thermometer must be provided and maintained in a suitable position. The Secretary of State may make regulations prescribing standards of reasonable temperature (which may vary from the above standard), and may prohibit the use of methods of heating which in his opinion are likely to be injurious to the persons employed.

It will have been noted that the general ventilation is required to be sufficient to render harmless any fumes (which term specifically includes gases and vapours), dust, or other impurity of industrial origin that may be dangerous to health. It is further required that where such substances are given off to such extent as to be likely to be injurious or offensive, or where there is any substantial quantity of dust of any kind, all practicable measures must be taken to protect employees from inhaling the dust or fume, and to prevent its accumulation. Where practicable, exhaust appliances must be provided and maintained as near as possible to the point of origin of the dust or fume, so as to prevent it entering the air of the workroom.

Apart from the requirement of a minimum temperature of 60° F. for sedentary workers, no other minimum temperature is prescribed as a general provision, but for specific industries or groups of industries special provisions are made. Thus in laundries, effective steps must be taken, by the employment of fans or otherwise, to regulate the temperature in every ironing room, and to carry away the steam in every washhouse. Workers must be protected from the heat arising from stoves used for heating irons, and no gas iron emitting noxious fumes may be used.

Some industrial processes, notably some in the textile industry, require a high atmospheric humidity for their efficient performance, and it is the practice to moisten the atmosphere artificially to obtain the required degree of humidity. The Cotton Cloth Factories Regulations, 1929, order that no artificial humidification shall be carried out when the wet bulb temperature exceeds 72½° F., or when the difference between the dry and wet bulb temperatures is less than that specified in the Schedule to the Regulations (2° at dry bulb temperatures up to 70° F., and then increasing to 3½° at 76° F.). The minimum permissible temperature in a 'humid' shed is 50° F. during the first half-hour, and 55° F. thereafter. It is also specified that no person shall be exposed at work to the direct draught from an air inlet, or to any draught at a temperature of less than 50° F. To ensure a reasonable fresh air supply it is prescribed that in 'humid' sheds the CO_2 content of the air may not be more than 8 parts in 10,000 in excess of the proportion present in the outside air; and in 'dry' sheds the excess must not be more than 11 parts in 10,000.

The Act of 1937 contains somewhat similar provisions for other humid factories—a 'humid factory' being a factory in which atmospheric humidity is artificially produced, by steaming or other means in connection with any textile process. In rooms where certain spinning or combing operations are carried on artificial humidification must cease when the wet-bulb temperature exceeds 80° F. and in other rooms when it exceeds 72½° F. Humidification must also cease when the depression of the wet-bulb temperature below the dry bulb figure is less than the minimum prescribed in a Schedule to the Act. The scheduled scale is very similar to that prescribed for cotton cloth factories, viz. a depression of 2° at temperatures up to 70° F., with a scale of increasing differences at higher temperatures so that at 86° F. the depression must be at least 6°, i.e. the wet-bulb temperature must not exceed 80° F. when the dry-bulb thermometer records 86° F.

Various regulations for dangerous trades specify the minimum temperatures that must be maintained, set standards of air purity, and require local exhaust ventilation of prescribed efficiency.

(ii) **Offices.** In the Offices Regulation Bill of 1926 provisions aiming at the prevention of overcrowding and the maintenance of suitable ventilation were included, but the Bill fell through. The definition of 'workplace' in the Public Health Act, 1936, embraces all places of clerical employment and removes all doubt which previously existed as to the extent to which local authorities had control over the conditions in offices. That Act empowers a local authority to take action to prevent insufficient ventilation or uncleanness or obnoxious effluvia in offices. A Ministry of Health Circular (No. 1600, May 1, 1937) reminds local authorities that it is their duty to cause their district to be inspected from time to time for the detection of statutory nuisances, and any authorized officer of the local authority has right of entry to offices at any time. The circular expresses the Minister's opinion that it is of great importance to national health that conditions in offices should not be such as to be prejudicial to the health of the employees, and local authorities are urged to arrange for the systematic inspection of offices in their areas with a view to ascertaining the conditions and the need for improvement.

(iii) **Shops.** Local authorities are charged with the supervision of working conditions in shops. The Shops Act, 1934, requires that suitable and sufficient means of ventilation shall be provided, and suitable and sufficient ventilation maintained; and that there shall be suitable and sufficient means to provide a reasonable temperature, and that a reasonable temperature shall be maintained.

II. The Thermal Environment

Considerable energy changes take place within the living body, all the energy being derived from

the oxidation of foodstuffs. A man doing moderate work has total energy requirements amounting to roughly 3000 large calories (or about 12,000 B.T.U.) per day. Much of this energy is evolved as heat. Even when the body is at rest and in warm surroundings, the heat production does not fall below a definite minimum level—the basal metabolism. When physical work is being performed the heat production rises. For many tasks the gross mechanical efficiency of the body is of the order of 20 per cent., the remaining 80 per cent. of the energy expended appearing as heat. Thus it is that in a cold environment one can keep warm by taking exercise.

In health, the mouth temperature and the temperature of the deeper tissues vary but slightly. Constancy of the body temperature, in spite of variations in environmental conditions, is achieved partly by the choice of suitable clothing, and partly by the action of physiological mechanisms which regulate (a) the rate of heat production within the body, and (b) the rate of heat loss from the body's surface. The metabolism remains almost steady at a minimum value over a fair range of temperature (roughly 70° to 85° F.), and at temperatures above or below this range it increases.

When a freely exposed object is at a temperature above that of its environment, it loses heat (i) by radiation to the surfaces which surround it, (ii) by convection to the surrounding air, and, if its surface is moist, (iii) by evaporation.

The rate of heat loss by radiation depends on the nature of the surfaces (of the cooling object and its surroundings) which are concerned in the radiation exchange, and on the difference between the fourth powers of the absolute temperatures of those surfaces. The rate of heat loss by convection depends on the temperature and velocity of the air, and also on the size and shape of the body. Evaporation is affected by the temperature of the surface and its degree of wetness, and by the temperature, humidity and velocity of the air. The human body loses heat by these different paths, but the rate of loss is largely influenced by vaso-motor control of the skin temperature, and by variations in the rate of insensible perspiration and sweating. In calm air, under comfortable indoor conditions, roughly half the heat loss from the clothed body is by radiation, while convection and evaporation each account for about a quarter of the total loss. Increased air movement increases the loss by convection and reduces that by radiation. At high temperatures evaporation comes more and more into play, until, when the environment is at the same temperature as the body, it is the only mode of heat loss.

The environmental factors which affect the heat loss from the body, and which govern our feelings of warmth, are, then, the temperature, humidity and rate of movement of the air, and the temperature of the walls and other solid surroundings. If the thermal environment is to be completely described all these four factors must be taken into account. The measurement of thermal conditions is an important part of the investigation of heating and ventilation.

Measurement of Thermal Conditions

The air temperature is conveniently measured by means of the ordinary mercury-in-glass thermometer. For the determination of atmospheric humidity the sling hygrometer, consisting of wet- and dry-bulb thermometers, is a suitable instrument. The wet-bulb temperature is of importance in warm atmospheres, and from the observed dry- and wet-bulb temperatures the humidity of the air, relative or absolute, is readily ascertained by reference to psychrometric tables.

Low air velocities such as those commonly encountered indoors are easily measured by means of the kata thermometer (Hill, 1919; Bedford and Warner, 1933). Another valuable instrument for the measurement of low air velocities is the heated thermometer anemometer of Yaglou (1938). The ordinary kata thermometer with its polished glass bulb is susceptible to the influence of radiant heat. The formulae which are used for the calculation of

FIG. 1.—The Globe Thermometer.

air velocities from kata observations contain no term in radiation; it is assumed that the surfaces of the solid surroundings will be at the same temperature as the air. If the temperature of those surfaces is substantially above or below air temperature a corresponding error will be introduced when the air velocity is computed. To overcome this difficulty, Bedford and Warner (1933) advocated the use of kata thermometers with silvered bulbs. The burnished silver surface reflects nearly all the incident radiation, and thus reduces errors from that source to a minimum. The standard kata thermometer has a cooling range of from 100° to 95° F., so that if the air temperature is above about 90° F. observations are either very slow or impossible; indeed, at temperatures above 80° F. they become tedious. A high temperature kata, with a cooling range of 130° to 125° F. is available (silvered or plain) and this is far more convenient to use in hot surroundings.

The radiation from the solid surroundings can be measured by means of a sensitive radiation thermopile used with a suitable galvanometer. The apparatus is costly, however, and many observations are necessary at any one point in order that the radiation from the whole of the surrounding sphere

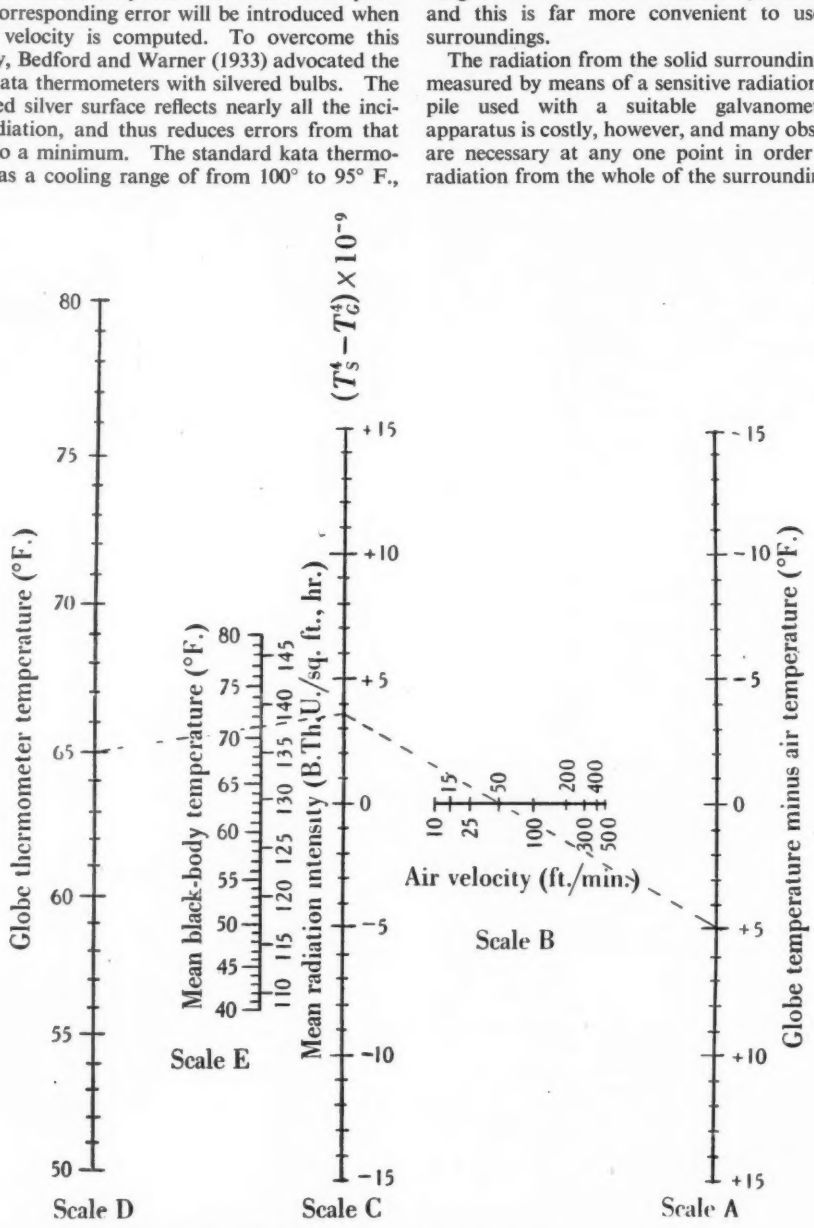

FIG. 2.—Chart for estimation of radiant heat from globe thermometer readings.

(Through the appropriate points on scales A and B a line is struck to cut scale C. From this intersection another line is drawn through the appropriate point on scale D. The intersection on scale E gives the measure of radiation.)

can be measured. The mean intensity of radiation, commonly expressed in terms of the mean temperature of the solid surroundings, or, as it is sometimes termed, the mean radiant temperature, can be calculated from readings of Vernon's globe thermometer if the air velocity and air temperature are known. The globe thermometer is a hollow copper sphere 6 inches in diameter, carrying a thermometer with its bulb at the centre of the sphere (fig. 1). The globe is painted matt black, and therefore absorbs virtually all the radiant heat incident upon it. Nomograms which enable the mean temperature of the surroundings to be read off without troublesome calculations have been published (Bedford and Warner, 1934; Bedford, 1937).

For a comparison of thermal environments it is convenient to express the combined effects of the contributory thermal factors in terms of a single index. Such an index is provided by the scale of *equivalent warmth* derived by Bedford (1936) from the results of a study of the thermal comfort of industrial workers. The equivalent warmth is the temperature of a uniform enclosure, with air and surroundings at the same temperature, and with the air still and saturated with water vapour, which would produce a sensation of warmth equal to that evoked by the combination of radiation and air temperature, velocity and humidity in question. The range established by that scale is rather limited, and further investigation is necessary to extend it to lower and much higher temperatures.

At temperatures below 65° or 70° F. considerable changes in atmospheric humidity have no profound effect on feelings of warmth, so that at such temperatures, which are those most commonly encountered indoors in Great Britain, the effects of humidity can be ignored in assessing the warmth of the environment. The remaining three thermal factors, the temperature and rate of movement of the air, and radiation, are taken into account by the scale of *equivalent temperature* (Dufton, 1932–6). Equivalent temperature is measured by means of an instrument known as the eupatheoscope (or comfort indicator), which is a heated, blackened cylinder, 22 inches high and 7½ inches in diameter. The heat input is regulated so that, whatever the temperature of the room, the surface temperature of the instrument corresponds with the mean surface temperature of the clothed human body. The equivalent temperature of an environment is that temperature of a uniform enclosure in which, in still air, the body would lose heat at the same rate as in the environment. Equivalent temperature can be estimated from readings of the globe thermometer, the kata thermometer and the ordinary mercury-in-glass thermometer (Bedford, 1936).

When the temperature rises above about 70° F.

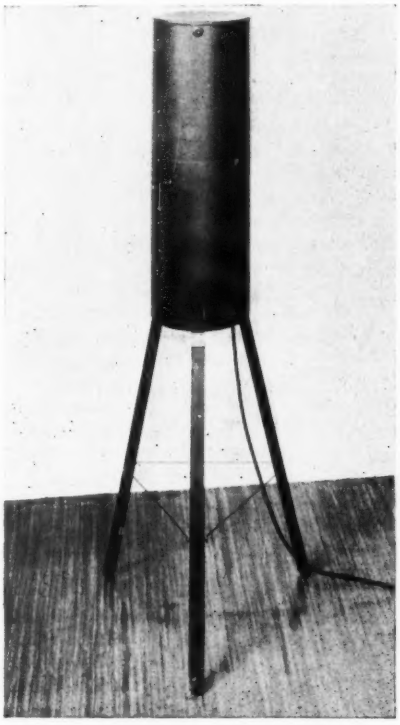

FIG. 3.—The Eupatheoscope.

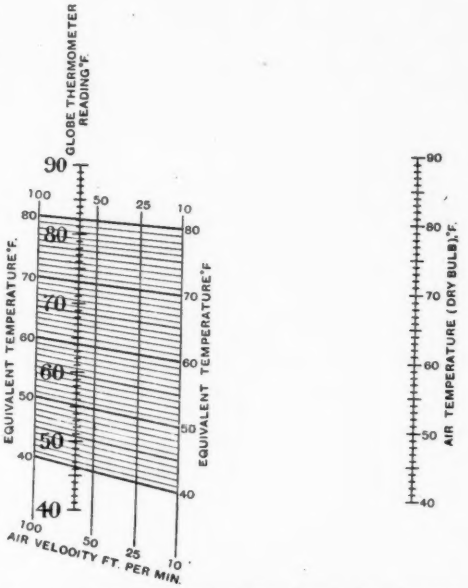
GLOBE THERMOMETER READING °F.
EQUIVALENT TEMPERATURE °F.
EQUIVALENT TEMPERATURE °F
AIR VELOCITY FT. PER MIN.
AIR TEMPERATURE (DRY BULB) °F.

FIG. 4.—Chart for the estimation of equivalent temperature from globe thermometer readings.

evaporation from the body surface becomes more important and the humidity of the atmosphere must be taken into account in assessing the warmth of the environment. The scale of warmth most widely used in America, where indoor temperatures are customarily maintained at higher levels than in Great Britain, is known as *effective temperature* (Yaglou, 1926). This scale takes into account the combined effects of the temperature of the air and of its humidity and rate of movement. Radiation is not specifically taken into consideration. Where the temperature of the solid surroundings is the same as that of the air effective temperature gives an adequate measure of the warmth of the environment, but it is not adequate when those temperatures differ appreciably.

Since the temperature of the globe thermometer is influenced by the air temperature and air velocity as well as by radiant heat, globe thermometer temperatures can also be used as indices of warmth. When Vernon (1932) introduced the glove thermometer it was his intention that it should be so used.

The kata thermometer was also intended primarily as a measure of warmth. The rate of heat loss from its bulb was said to give an indication of the cooling power exerted by the environment on the body. Readings obtained by the dry instrument have therefore been referred to as ' dry kata cooling power,' and those obtained when the bulb was covered with a wet finger stall are termed ' wet kata cooling power.' The former takes into account cooling by convection and radiation, while the latter is also influenced by evaporation. The use of the dry kata cooling power for the computation of air velocities is a later development. There are serious physical objections to the kata thermometer as an

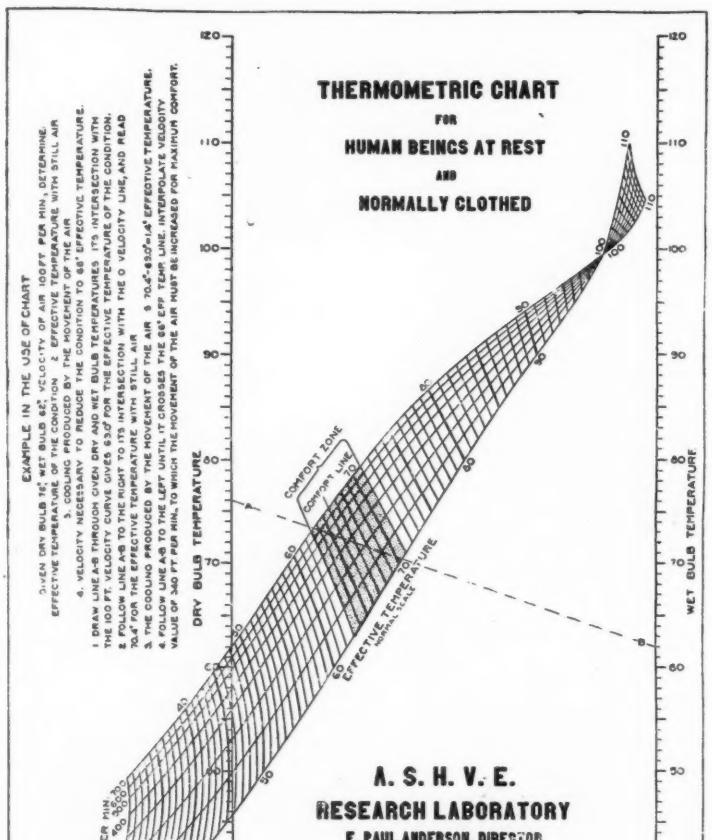
THERMOMETRIC CHART
FOR
HUMAN BEINGS AT REST
AND
NORMALLY CLOTHED
EXAMPLE IN THE USE OF CHART
GIVEN DRY BULB 78°, WET BULB 62°, VELOCITY OF AIR 100 FT PER MIN., DETERMINE:
EFFECTIVE TEMPERATURE OF THE CONDITION 2. EFFECTIVE TEMPERATURE WITH STILL AIR
3. COOLING PRODUCED BY THE MOVEMENT OF THE AIR
4. VELOCITY NECESSARY TO REDUCE THE CONDITION TO 68° EFFECTIVE TEMPERATURE.
1. DRAW LINE A-B THROUGH GIVEN DRY AND WET BULB TEMPERATURES ITS INTERSECTION WITH
THE 100 FT. VELOCITY CURVE GIVES 63.0° FOR THE EFFECTIVE TEMPERATURE OF THE CONDITION.
2. FOLLOW LINE A-B TO THE RIGHT TO ITS INTERSECTION WITH THE 0 VELOCITY LINE, AND READ
70.4° FOR THE EFFECTIVE TEMPERATURE WITH STILL AIR.
3. THE COOLING PRODUCED BY THE MOVEMENT OF THE AIR IS 70.4°-63.0°=7.4° EFFECTIVE TEMPERATURE.
4. FOLLOW LINE A-B TO THE LEFT UNTIL IT CROSSES THE 68° EFF. TEMP. LINE. INTERPOLATE VELOCITY
VALUE OF 340 FT PER MIN., TO WHICH THE MOVEMENT OF THE AIR MUST BE INCREASED FOR MAXIMUM COMFORT.
DRY BULB TEMPERATURE
WET BULB TEMPERATURE
COMFORT ZONE
COMFORT LINE
EFFECTIVE TEMPERATURE
NORMAL SCALE
VELOCITY OF AIR IN FT. PER MIN.
A. S. H. V. E.
RESEARCH LABORATORY
F. PAUL ANDERSON, DIRECTOR
IN COOPERATION WITH
U. S. BUREAU OF MINES
PITTSBURGH PA.
C. P. YAGLOGLOU W. EDW. MILLER

FIG. 5.—Effective temperature chart for persons at rest and normally clothed.

instrument for indicating the warmth of the environment. The bulb, although large for a thermometer (2 cm. diameter and 4 cm. long) is very small in comparison with an object the size of the human body. The convection loss per unit surface area is greatly influenced by the size of the cooling object: the heat loss per square centimetre of surface is much greater in the case of the kata thermometer than in that of the human body, when the temperature difference is the same. For this reason, in comparison with the human body, the kata thermometer is unduly sensitive to changes in air velocity —it makes far too much allowance for convection. This disability as a measure of the overall degree of warmth makes the kata thermometer a very valuable instrument for use as an anemometer.

Warmth and Comfort

With these various instruments and scales of warmth available, it was obviously desirable that we should know something about their reliability as indices of comfort. An investigation of this problem is reported by Bedford (1936). It was carried out in a number of British factories during the winter months when artificial heating was in use. The subjects were all engaged in light industrial occupations. Ninety-four per cent. of the observations were made on females, and these were mostly young women and girls. At each observation position instrumental measurements of the thermal environment were made, while the workers in the immediate neighbourhood were questioned as to their state of warmth. Measurements were then made of the skin temperatures of the foreheads, hands and feet of the workers, and of the mean surface temperatures of their clothed bodies. In all, over 3000 sets of observations were made. The replies of the workers as to their feelings of warmth were recorded on a seven-point scale of warmth sensations:

1. Much too warm.
2. Too warm.
3. Comfortably warm.
4. Comfortable.
5. Comfortably cool.
6. Too cool.
7. Much too cool.

Statistical examination of the correlation between these 'comfort votes,' as they have been termed, and the various indices of warmth showed that, over the range of environmental conditions covered by the investigation, of the indices taken into consideration equivalent temperature was most closely associated with comfort votes. Globe thermometer temperature was practically as good an index as equivalent temperature, while effective temperature and the dry-bulb temperature of the air were bracketted in the third place. Dry kata cooling power was emphatically a poorer index of warmth than even the simple air temperature.

For the conditions that may be encountered indoors during winter in Great Britain, there can be no doubt that equivalent temperature is the most preferable index of warmth: it makes adequate allowance for radiation and air movement as well as temperature. Where a wide range of air movement may be met with the globe thermometer is at a disadvantage, but in calm air conditions such as usually prevail indoors it is a valuable index. Where any appreciable radiation has to be taken into account, as in the vicinity of high-temperature sources such as open fires, or near large windows or thin, cold walls, equivalent temperature or globe thermometer temperature should be used. But where radiation effects are known to be negligible, as is often the case in a building with convective heating, and where the air is calm, the reading of the much maligned ordinary thermometer is a valuable index.

The feeling of warmth experienced by a person is not dependent solely on the warmth of his environment. Differences in clothing, in muscular activity, in nutrition, age and general bodily build and, not least, in acclimatization, all tend to influence the feelings of warmth experienced by different persons in the same environment. Consequently, it often happens that in a room in which most people are comfortable some feel too warm while others are too cool. Such differences were encountered in the investigation now being described. Measurements of warmth, such as equivalent temperature or air temperature, give a very reliable indication of the average response of a group of people, but they are of little use for predicting the responses of individuals. Similar difficulties experienced by earlier workers led to the suggestion that the temperature of the skin, e.g. of the forehead, would be found to be a better indication of individual comfort, and a good deal of reliance was placed on such measurements by some German researchers. However, this investigation showed quite clearly that skin temperature measurements were unreliable for that purpose.

(i) **Winter Temperatures.** When one has to prescribe the temperature that is to be maintained in a room where many people are employed, as in a factory or large office, the best that can be done is to ensure the comfort of as many people as possible —it is difficult or impossible to please everybody. Unless the temperature of the building is under automatic control, it is impracticable to keep it exactly at a preordained level day in and day out. Changes in external conditions and the effects of prolonged occupation cause fluctuations, and when manual control has to be relied upon temperature variations will occur. Such variations should be kept within the comfort zone. For persons doing light industrial work during the winter months, Bedford found the comfort zone to range from 58° to 66° F. equivalent temperature; from 62° to 68° F. as indicated by the globe thermometer; or, in terms of the ordinary air temperature, from 60° to 68° F. It is noteworthy that this lower figure of 60° F. coincides with the minimum temperature prescribed by such workers in the Factories Act.

Persons doing harder physical work do not

require temperatures as high as those mentioned. It is recommended (Industr. Hlth. Res. Bd., 1940) that for active yet light work the temperature should be between 60° and 65° F., and that for work necessitating more muscular exertion it should be 55° to 60° F.

(ii) **Summer Temperatures.** In hot weather it is usually impossible to keep factory temperatures within the limits mentioned above, nor is it desirable that such temperatures should be maintained. In summer we become acclimatized to higher temperatures and make adjustments to clothing, so that temperatures that would be entirely satisfactory in winter would be found chilly in summer. In a well-ventilated building it should be possible to keep the temperature to within a degree or two of the outside temperature, unless industrial processes give off much heat.

If a full-scale air-conditioning plant is installed, so that cooling is possible, the temperature should not be lowered too far in the hot weather. Yaglou (1941) has shown that exposure to a sudden temperature drop of 10° F. or more in hot weather is harmful to a considerable proportion of persons, for the skin and clothing are wet with perspiration and rapid chilling occurs. This initial chilling, which usually lasts only a few minutes, suppresses sweating and may reduce one's ability to withstand heat for some time after returning to the hot atmosphere. For summer air conditioning, dehumidification of the air, with but little reduction of temperature, seems to be indicated.

Draughts

On the question of what constitutes a draught, as with other questions relating to warmth, there is much divergence of opinion. Some people enjoy and find refreshing cool air currents which provoke others to angry complaint. The velocity at which a current of air becomes noticeable depends on its temperature. At ordinary room temperatures Baetjer (1924) found that currents impinging on the skin of the cheek with velocities below about 40 to 60 feet per minute were not perceptible. But some people complain of draughts when the air velocity is as low as 20 feet per minute. Investigating such complaints, Bedford (1936) found that those who complained tended to have skin temperatures somewhat below the average, and that, probably partly on that account, they required for comfort an environment about 4° F. warmer than that found satisfactory by the average person.

Cold Feet

Chilliness of the feet can be a potent cause of discomfort. About 5 per cent. of Bedford's subjects volunteered complaints of cold feet. Some complained even when the temperature of the air near the floor was nearly 70° F., but the frequency of complaints increased as the temperature diminished. The complaints could scarcely be ascribed to the effects of strong draughts about the feet, for the air velocity near the floor was less than 50 feet per minute in 88 per cent. of the complaints, and in 45 per cent. it was less than 30 feet per minute. Measurements showed that the feet of the complainants were on the average slightly cooler than those of their fellows, but the difference of 2° F. was only small in comparison with the variation that was found to occur in foot temperature when air temperature was held constant. Those who complained of cold feet, like those who were upset by draughts, were chilly mortals. For comfort they required a room temperature 5° F. warmer than that required by the average population. With a given skin temperature they felt cooler than their fellows.

Freshness or Stuffiness

It often happens that when one has no complaint to make about the warmth of a room, that is, when one is neither too warm nor too cool, one remarks that the room seems stuffy or oppressive, or that it feels fresh and invigorating. Impressions of freshness or stuffiness are not the same as sensations of warmth, and it is necessary to distinguish between them. In two rooms the overall degree of warmth, say the equivalent temperature or the equivalent warmth, may be the same, yet one room may feel fresh and the other stuffy. Feelings of freshness or of stuffiness are mainly conditioned by the thermal environment, and thus they are to some extent correlated with feelings of warmth. On the whole, a cool room tends to feel fresh, while an overheated one feels stuffy. Feelings of warmth depend on the effect of the environment on the heat-regulating mechanism of the body, while sensations of freshness or of stuffiness appear to be evoked by the stimulation or lack of stimulation of the skin by the environment. This stimulation is largely due to air movement, but the other thermal factors also exert their effects.

During the war of 1914–18, the Health of Munition Workers Committee defined an invigorating atmosphere as being: (i) cool rather than hot; (ii) dry rather than damp; (iii) diverse in its temperature in different parts and at different times rather than uniform and monotonous; and (iv) moving rather than still. Sir Leonard Hill had already shown the enervating effects of excessive warmth and humidity and of stagnation of the air.

Vernon, Bedford and Warner (1926), and later Bedford and Warner (1939) studied the effects of the environment on subjective impressions of freshness. From a statistical examination of observational data, and after a discussion of the bearing of other factors not covered by those observations, the latter authors stated the requirements for a pleasant and invigorating atmosphere. These are:

(i) A room should be as cool as is compatible with comfort.

(ii) There should be adequate air movement. At the room temperatures customarily maintained in winter in Great Britain the velocity should be about 30 feet per minute; velocities below 20 feet per

minute tend to cause feelings of stuffiness. In summer weather, or in hot factories, higher rates of air movement than those mentioned are desirable.

(iii) The air movement should be variable rather than uniform and monotonous, for the body is stimulated by ceaseless change in the environment. Ventilation by open windows is likely to give variable air movement, but in mechanical ventilation installations the inlets should be so designed, and the velocity of discharge so arranged, that suitable eddying currents are set up.

(iv) The relative humidity of the air should not exceed 70 per cent. and should preferably be much below that figure.

(v) The average temperature of the walls and other solid surroundings should not be appreciably lower than that of the air, and should preferably be warmer. The combination of cold walls and warm air often causes feelings of stuffiness.

(vi) The air at head level should not be distinctly warmer than that near the floor, and the heads of the occupants should not be exposed to excessive radiant heat.

(vii) The air should be free from objectionable odours.

It will be noted that variable air movement is specified as desirable. Out of doors we are braced by the changing play of the wind, and indoors, too, the variations of air velocity that occur in a well-ventilated room exert a beneficial effect. By means of a hot-wire anemometer, Vernon, Bedford and Warner measured air velocities at 2½ seconds intervals, and their results clearly show that, with a constant average air velocity, increased variability of movement evokes feelings of greater freshness.

Low relative humidities are advocated. It is often thought, especially when buildings are mechanically ventilated, that the air of warmed rooms becomes too dry during the winter. In Great Britain, during cold weather when the water content of the outside air is very low, the relative humidity may be about 30 per cent. or even lower; yet under such conditions the writer has never found evidence that the air was too dry. The New York State Commission on Ventilation (1923, p. 197) found that exposure for 8 hours a day on 5 days a week to an atmosphere at 75° F. with a relative humidity of 25 per cent. did not produce any demonstrable harmful effects. Liese (1933) reported that at temperatures of 65° to 69° F. no discomfort was felt with relative humidities as low as 25 per cent., but that some unpleasantness was experienced when a sudden severe spell reduced the indoor humidity to 12 per cent. It appears from this that the moisture content of the air must be low indeed before any ill-effects are felt.

It is true that recently Winslow, Herrington and Nelbach (1942) have shown that when the vapour pressure falls below 0·4 inch of mercury, there is a distinct drying at the back of the throat. Such drying occurs at temperatures below 53° F. with any moisture content up to saturation, at 60° F. with less than 77 per cent. relative humidity, and at temperatures of 70° and 80° F. with less than 54 and 39 per cent. humidity respectively. But at the conclusion of their paper these authors remark that although they have demonstrated this drying they have no evidence that it is undesirable. If such drying is harmful, they say, its influence must be present in cold, dry air as well as in hot, dry air.

III. Fresh Air Requirements

Under any ordinary conditions of occupation the air of a room is never likely to become vitiated to such an extent that the oxygen content is low enough, or the carbon dioxide content high enough, to occasion discomfort. The old idea that the discomfort experienced in crowded rooms was due to an excess of CO_2 is disproved. Ventilation is bad if the CO_2 content reaches 0·5 per cent., but CO_2 exerts no sensible physiological effect until its concentration is about 2½ to 3 per cent., when the depth and frequency of respiration become slightly increased. The main discomfort in crowded rooms arises from the thermal effects that have already been discussed, and the maintenance of a suitable physical environment is one of the cardinal requirements of ventilation. But in addition, ventilation is necessary to remove body odours and the organisms discharged by sneezing and coughing, and where toxic dusts, gases or vapours are liberated into the atmosphere the ventilation must also be sufficient to ensure that the concentrations of these substances are kept below their danger thresholds.

Removal of Body Odours

During the past century standards of the minimum desirable fresh air supply for occupied rooms have been put forward from time to time. Reid (1844) arrived at the figure of 600 cubic feet of fresh air per derson per hour. He gave this ' with much diffidence, and only as an approximation.' His estimate was, however, based on ' an extreme variety of experiments made on hundreds of different constitutions,' and in some cases his subjects were enclosed in a cabinet in which the quality and quantity of the air could be controlled. For barrack rooms, Roscoe (1857) and the Barrack and Hospital Commission (1861) recommended 1200 cubic feet per person per hour. De Chaumont (1875) found that odours were only just perceptible when the air supply was 1500 cubic feet per hour, whereas a supply of 3000 cubic feet was necessary to provide an atmosphere not sensibly different from the outside air; he advocated the higher standard.

More recently much research has been done by Yaglou and his colleagues (1936). Again, the absence of disagreeable odours was taken as the criterion of a satisfactory ventilation rate. It was shown that the intensity of body odour depended greatly on the personal habits of the occupants. Abstention from baths during an experimental week caused the fresh air requirements for odour control to increase day by day. Presumably because of differences in personal habits, and in the bathing facilities available, persons of the poorer social

grades required more fresh air than did those of higher status; and the requirements of school children were commonly greater than those of adults. Yaglou and his associates set out in detail the fresh air requirements for various types of persons, but from their data it can be concluded that, as a round figure, a minimum fresh air supply of about 1000 cubic feet per person per hour is necessary if the concentration of body odours is to be unobjectionable to persons entering from relatively clean air.

Sometimes it is suggested that such a ventilation rate is unnecessarily high, that people commonly like a 'frowst,' and do not object to odours, and that in the interests of economy of heating lower ventilation rates are permitted. People vary in their response to body odours; some do not seem to object to them, while to others they are most objectionable. But even if some people have often through necessity become accustomed to breathing a foul atmosphere, that is no good reason why they should be expected to do so. We have for many years gone to great pains to safeguard our water supplies, and a high standard of purity is demanded in the case of foodstuffs. Surely one has a right to live and work in an atmosphere that is free from objectionable odours.

There is evidence that body odours are undesirable on other than aesthetic grounds. Winslow and Palmer (1915) found that there were substances present in the air of an occupied room which, in some way, and without producing conscious discomfort or detectable physiological symptoms, diminished the appetite for food. Later, Winslow and Herrington (1936) showed a statistically significant reduction of appetite in the presence of odours.

Reid (1844) tells an amusing story to illustrate the effects of ventilation on the appetite. He says:

> Some years ago, about 50 members of one of the Royal Society Clubs at Edinburgh, dined in an apartment I had constructed, where, though illuminated by gas, the products of its combustion were essentially excluded, as they were all removed by a ventilating tube connected with, but concealed in, the drop of the gothic pendant in which the central lights were placed. Large quantities of a mild atmosphere were constantly supplied, and passed in quick succession through the apartment throughout the whole evening, the effect being varied from time to time by infusing odoriferous materials, so that the air should imitate successively that of a lavender field, of an orange grove, etc. Nothing very special was noticed during the time of the dinner by the members; but Mr. Barry, of the British Hotel, who provided the dinner, and who, from the members of the club being frequently in the habit of dining at his rooms, was familiar with their constitutions, showed the committee that three times the amount of wines had been taken than was usually consumed by the same party in a room lighted by gas, but not ventilated—that he had been surprised to observe that gentlemen whose usual allowance was two glasses, took, without hesitation, as much as half a bottle—that those who were in the habit of taking half a bottle, took a bottle and a half, and that, in short, he had been compelled twice to send hackney-coaches for additional supplies during dinner, though he had provided a larger supply than usual, considering the circumstances under which the members met.
>
> Minute inquiries afterwards assured me that no headache nor other injurious consequence followed this meeting, nor were any of the members aware, at the moment, that they had partaken more heartily than usual, till Mr. Barry showed them what had taken place. The meeting included individuals of all ages and of extreme variety of occupations, among whom were judges and members of Parliament, medical men and members of the bar, naval and military officers, whose different ages varied as much as their very various professional occupations.

Air Movement

Increased ventilation commonly means more air movement, though the statement does not apply without exception. In warm weather we throw open our windows to get more air movement. But substantial increases in the ventilation rate are necessary to gain appreciable increments in the air movement. This is shown by observations, as yet unpublished, made by the writer and his colleagues. Thus, in a closed room with less than one air change per hour the velocity was 10 or 11 feet per minute, while to raise the velocity to 20 feet per minute by natural ventilation it was necessary to raise the ventilation rate to twenty air changes per hour. In factories the movement of persons and machinery tends to cause increased air movement, and in a factory building the air will probably not be very stagnant if the fresh air supply reaches the recommended figure. But in summer much more ventilation than that necessary to remove odours is very desirable. Copious ventilation is desirable in summer, on physical grounds as well as for the removal of odours.

Air-borne Infection

Bacteria-laden droplets discharged in sneezing and coughing may be spread over a distance of 15 feet or so. They vary in size. The larger ones fall to the ground fairly quickly; but the smaller ones fall slowly, and as evaporation reduces their size many become so small that, like fine dust particles, they remain air-borne for considerable periods. Those organisms which reach the floor may survive on dust nuclei which after disturbance may again become suspended in the air.

In recent years renewed attention has been given to the question of air-borne infection. It has been shown that organisms and viruses released into the air in one part of a building can be recovered in other parts (Wells, 1935 ; McCoy, 1934 ; Dalla Valle and Hollaender, 1940). Influenza virus has been recovered up to one hour after its suspension (Wells and Brown, 1936). There seems to be no real evidence as to the relative importance of direct droplet infection and air-borne infection in the transmission of respiratory disease, but there is clear evidence that air-borne infection can occur.

Cruickshank and Muir (1940) believed that an outbreak of streptococcal infection had been aerially spread.

Clearly, then, the concentration of pathogenic organisms in the air of a room should be kept as low as possible. The concentration can be reduced by increased ventilation or by the use of some bactericidal agent. Much work has been devoted to testing the value of ultra-violet light and of various germicidal sprays for aerial disinfection. Discussing the results obtained, Andrewes (1940) remarks that no method for the control of infection is as effective as adequate spacing of individuals combined with adequate ventilation. Methods such as ultra-violet light and mists are, he says, of value only as second-rate substitutes where proper spacing and ventilation cannot be achieved.

Ozone

Commercial pamphlets have made great claims for ozone as a means of reducing ventilation costs and enhancing health and comfort. Ozone is said to destroy odours and to sterilize the air, and valuable physiological effects have been claimed for it.

Experimenters in the Rand mines could detect no difference in the working capacity or resistance to fatigue, or in various other bodily reactions, when ozone was added to the air (Weiner, 1938). It is difficult to understand how minute traces of ozone could have any sensible effect on the metabolism, as has been claimed, and Weiner's statement seems to dispose of such claims.

Even in very low concentrations ozone is a powerful irritant. Concentrations of 0·1 to 1 part per million irritate the respiratory membranes, and exposure to such concentrations shortens the lives of guinea-pigs. The irritation threshold appears to be about 0·05 part per million, and distinctly lower concentrations do not appear to injure health. The olfactory threshold level for those with a keen sense of smell was confirmed by Witheridge and Yaglou (1939) to be 0·01 part per million parts of air, while 0·015 part per million was detectable by most normal persons. All normal persons objected to 0·1 part per million, and Witheridge and Yaglou recommended that 0·04 part per million should be regarded as the upper permissible limit in occupied rooms.

It was found by Witheridge and Yaglou that ozone in the just-detectable concentration of 0·015 part per million reduced the smell of body odours enough to allow of a reduction of 50 per cent. in the fresh air requirement for odour control. Lower concentrations of ozone were valueless. There is, however, a great difficulty in the way of any application of this finding to secure a reduction of ventilation costs. With a given output of ozone its concentration in the air of a room may vary within wide limits according to the atmospheric humidity. A constant ozone output may yield only a trace of ozone on a humid day, while on a dry day the concentration may be undesirably high. Hence, Witheridge and Yaglou advise that until adequate means for accurately controlling ozone concentrations are available the use of ozone in occupied rooms should be discouraged.

Elford and von den Ende (1942) found that ozone in concentrations not exceeding the upper permissible limit of 0·04 part per million could inactivate certain unprotected organisms in atmospheres of 60 to 90 per cent. relative humidity; but when such bacteria were covered with a protective coating of organic matter, as in the sprays naturally emitted during coughing or sneezing, ozone in permissible concentrations had no significant effect. Inactivation of such protected organisms required ozone concentrations which must be deemed dangerous for long spells of breathing.

This evidence leads to the conclusions that ozone is not a practicable germicide for use in ventilation, and that until its concentration can be accurately controlled it is not suitable for use in combating body odours.

Dusts, Vapours and Gases

One function of factory ventilation is to remove deleterious gases, vapours or dusts that may escape into the air of a workroom. It should be emphasized, however, that every effort should be made to prevent the dispersion of such substances with the atmosphere. Sometimes this can be done by substituting harmless substances for toxic ones. Where such substitution is impossible, it may be practicable to arrange for the total enclosure of the process, so that there there can be no escape of the deleterious substance. Failing total enclosure, carefully designed local exhaust ventilation will often provide a solution. There are cases where even local exhaust ventilation is not practicable, and then recourse has to be had to increased general ventilation.

When considering general ventilation from this standpoint, it is not sufficient to ensure that the average concentration of the toxic material is below the danger threshold. The concentration in the neighbourhood of the worker is likely to be distinctly higher than that for the room as a whole, and it is the purity of the air breathed by the worker that matters.

A code of maximum permissible concentrations of various atmospheric contaminants is being prepared for the American Standards Association, but the standards used in Massachusetts have already been published by Bowditch and others (1940). Where toxic substances have to be dealt with by general ventilation the fresh air requirements will obviously be governed by the quantities of air necessary to dilute these substances, rather than by those needed for odour control.

Measurement of Fresh Air Supply

The ventilation rate can be ascertained directly by measuring the flow of air into or out of a room, or indirectly by measuring the change of concentration of some gas or vapour added to the atmosphere.

Direct measurement is usually the method of

choice when ventilation is by fans. At fan outlets, or at the air inlets or outlets in individual rooms, the velocity of air flow can generally be measured by means of a vane-type anemometer, and thus the quantity of air passing is readily arrived at. When measurements of the flow through ducts are needed they are generally computed from determinations of pressure differences made with Pitot tubes.

In some buildings with natural ventilation, too, direct measurements of ventilation are possible. The velocity of flow through each ventilation opening can be determined by using a vane anemometer, and the area of each opening is easily measured. Thus the rate of air flow (cubic feet per minute) through each opening is known, and it is usually found that the estimates of total flow through inlets and through outlets correspond remarkably well. This method has frequently been used by the writer and his colleagues in factory buildings.

Ventilation rates in small rooms, such as those in dwellings or in some offices, have frequently been estimated from changes in the composition of the air, and most commonly from variations in the carbon dioxide content.

If the only source of added CO_2 is the air exhaled by the occupants, and if occupation has been continuous for an hour or two so that the composition of the air has approximately reached its equilibrium level, the ventilation rate can be estimated by measuring the concentration of CO_2. For sedentary persons, or those lightly occupied, the CO_2 production amounts to about 0·6 cubic feet per hour, and this is the figure commonly assumed in such estimates. If k is the concentration of CO_2 in the room (parts in 10,000) the air supply per person, in cubic feet per hour, a, is found from the relation

$$a=\frac{6000}{k-4}$$

the concentration in the external air being taken as 4 parts in 10,000.

The result obtained by this method is not likely to be very accurate, but it will give a rough indication of the ventilation rate, and the method has the merit that it can be applied in occupied rooms.

Another method is to discharge into the room a quantity of some gas which is not a normal constituent of the air, and then measure the rate of decay of its concentration as it is diluted by the ventilating current. A convenient way of employing this method is to liberate hydrogen or coal gas, and then to measure its concentration with an electrical instrument known as a katharometer. If the ventilation rate is steady the concentration diminishes exponentially with time. Concentration plotted against time gives a typical die-away curve, while the logarithm of the concentration is linear with respect to time. Ventilation rates ascertained by this method are calculated, and commonly expressed, as the number of air changes per hour. If it is said that the ventilation rate is one air change per hour, it is meant that the volume of air entering and leaving the room during the period of one hour is equal to the cubic capacity of the room. It is not meant that no jot of the original air is left at the end of one hour. After one ' air change ' has taken place there remains in the room 36·8 per cent. of the original air. The katharometer method of measuring air change was used by Marley (1935). It has since been employed in an extensive investigation of the ventilation of dwellings by Warner (1940) and by Bedford, Warner and Chrenko (1943).

IV. Methods of Ventilation

Ventilating systems are divisible into two main groups, natural ventilation systems in which reliance is placed on natural forces without the aid of mechanical power, and mechanical systems in which power is used to drive fans.

Natural Ventilation

The two natural agencies that bring about natural ventilation are wind pressure and the force of gravity. The wind drives air in through openings on the windward side of the building so that it passes out on the leeward side. Passing over a chimney top or a roof cowl, the wind has an aspirating action on the air within the flue or cowl. Gravity effects are mainly due to temperature differences. Cool and relatively dense air displaces warmer and lighter air, so that convection currents are set up.

An unheated room provided with an open fireplace has a fair measure of ventilation due to the passage of the wind over the chimney, but when a fire is lit in the hearth, and the air in the flue is heated, the convection effect is added to the aspirating influence of the wind, and the ventilation rate is substantially increased. Or take the case of a factory building with roof cowls and with windows in the walls. When, as is usual, the temperature within the factory is above that outside, the warm air inside is displaced by the cool air entering at the windows, and it passes out through the roof cowls. This gravitational effect is supplemented by the influence of the wind.

(i) **Window Ventilation.** In narrow factory buildings of the width common in the multi-storey type, good cross-ventilation can usually be obtained by the provision of large and suitably placed windows.

Fig. 6 shows a good arrangement of windows in such a factory. The sides are almost wholly of glass, and in each glazed section there is a swivel frame at high level, and a hopper below. The swivel frames are $3\frac{1}{2}$ ft. by $3\frac{3}{4}$ ft. in size, and they can be fully opened. The hoppers are $3\frac{1}{2}$ feet wide and can be opened to a width of 10 inches. A noteworthy feature of the hoppers is that they are fitted with gusset-pieces at the sides: these serve to prevent draughts. It is a useful working rule that the opening area available for natural ventilation should be not less than 5 square feet for every 100 square feet of floor area. In the factory depicted in the figure the area of the window openings is more than 7 square feet per 100 square feet of floor. Measurements made in this factory during

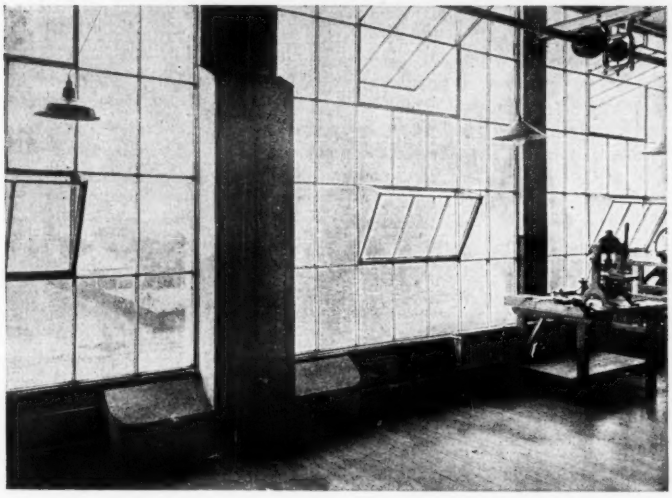

FIG. 6.—Good arrangement of hopper and swivel windows. Tobin tube also shown.

summer weather showed that, with only 40 per cent. of the available window area open, the ventilation rate was twenty air changes per hour, which figure represented a fresh air supply of 12,000 cubic feet per hour per operative (Vernon, Bedford and Warner, 1926*b*). Judged by the minimum fresh air standard of 1000 cubic feet per person per hour, mentioned earlier, this is lavish ventilation, but the windows were as the operatives had opened them from choice, and the conditions were distinctly pleasant. The air temperature was 68° F. and the speed of air movement 61 feet per minute.

Between the windows to the left of fig. 6 will be noticed a Tobin tube ventilator. Such air inlets are provided at intervals of 20 feet along the sides. Inside each tube there is concealed a hot-water radiator, whereby the entering air is warmed in winter, and the inlets are controlled by dampers. By means of these ventilators tempered air can be admitted in winter without the workers experiencing objectionable draughts. Air outlets are provided in the form of air gratings opening into vertical exhaust shafts. The arrangement of these is shown in fig. 7. There are four large shafts in the middle line of the building, and in each shaft are four separate flues, one from each floor. On the roof, at the top of each shaft, there is a louvred outlet, so that by the combined influence of gravity and the aspirating power of the wind, air is extracted upwards from the workrooms. By means of wire ropes in each workroom flaps are controlled by which any single flue can easily be shut off from the roof louvre and, instead, connected with a horizontal duct that leads to a large centrifugal fan situated beneath an outlet tower. Thus, on occasions when the ventilation by Tobin tubes and gravity exhaust flues is inadequate, and when it is not desired to throw the window open, satisfactory ventilation can be achieved by mechanical extraction.

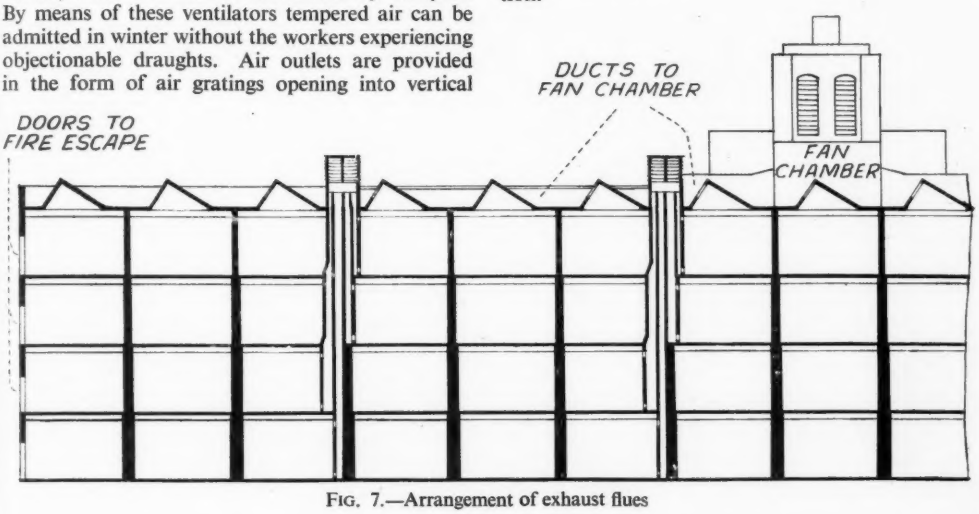

FIG. 7.—Arrangement of exhaust flues

In wider buildings, or where proper cross-ventilation is impracticable, window ventilation alone is often inadequate. In such factories though the localities near open windows have good ventilation, there are often considerable ' dead ' areas where the air is relatively stagnant. Frequently the conditions can be much improved by providing openings of liberal size in the roof, so that advantage can be taken of gravity effects. Such roof outlets are often in the form of louvres. Double-sided ridge louvres can be made to provide a large outlet area; they suffer from the disadvantage that with adverse winds they may become inlets and the down-draughts thus caused will provoke strong complaints in cold weather. Shutters can be provided so that the louvre facing the wind can be closed, but unless there is careful supervision trouble may still arise. Probably the best arrangement for natural ventilation through roof openings is the provision of modern stationary-type roof cowls These are so constructed that, whatever the horizontal direction of the wind, they maintain extraction. Such cowls, if of generous size and sufficient in number, can give very satisfactory results when proper arrangements are also made for the entry of fresh air.

Windows of the type illustrated in fig. 6 are excellent for factories of medium or large size, but in small workrooms, such as those found in converted dwelling-houses, good results can be obtained with the ordinary sash-window. In warm weather when the window is opened widely and the door is also open, ventilation will generally be ample. In winter, a fair amount of fresh air can usually be got without serious draughts by employing Hinckes Bird's arrangement. This merely consists of an accurately fitting block of wood, 3 or 4 inches deep, which is inserted below the lower sash. Thus no draught can enter at low level, but air can enter between the sashes and is directed upwards towards the ceiling. This arrangement would be of negligible value in a large workroom, since the amount of air thus admitted would be too small.

In many small rooms such as those just mentioned, and in many offices, chimney flues are provided. A chimney flue of the usual 9 in. by 9 in. cross-section is a valuable ventilating agent even when there is no fire alight at its base, but its ventilating effect is much increased when a fire is burning and the air in the flue thereby heated.

Mechanical Ventilation

Fans may be used to propel air into a room or to extract it. A system of ventilation in which the air is impelled into the room is known as a plenum or a propulsion system, and when the fans withdraw air from the room the installation is known as an extraction or exhaust system. Either system may be used alone, or the ventilation scheme may incorporate both impulsion and extraction.

The fans used for ventilation purposes are of two main types, propeller or disc fans and centrifugal or pressure fans. Propeller fans are used to move large volumes of air with only a low consumption of power. They are only efficient when the resistance to flow is negligible. They should not, generally, be used to move air through ducts, but if ducts cannot be avoided they should be short, as straight as possible, and of large cross-section. They should not be expected to work against a strong wind pressure.

Centrifugal fans are designed to move comparatively large volumes of air against considerable resistances. They are usually encased in metal and are so constructed that the air enters at a central inlet on one or both sides of the casing, and is discharged tangentially. These pressure fans are commonly employed in plenum ventilation installations, where the air has to be sent through long ducts, and in local exhaust systems for the removal of dust or fumes.

Useful information as to the characteristics of both propeller and centrifugal fans is given in Welfare Pamphlet No. 5, ' Ventilation of Factories,' issued by the Ministry of Labour and National Service.

Extraction Ventilation

One excellent example of extraction ventilation has been illustrated in fig. 7. This method of ventilation can be used to ensure effective cross-ventilation in narrow rooms, by placing propeller fans in exhaust openings at suitable intervals in one side wall and providing adequate air inlet opening in the opposite walls. Provision should be made for warming the incoming air, and such provision may well be in the form of the Tobin tubes seen in fig. 6 with radiators encased therein. The air inlets should be of large size, so that the inlet velocities are kept low and draughts thereby avoided. When, as is very often the case, the exhaust fans are mounted in openings in an external wall, they should be protected by wind shields. More effective protection from adverse winds is obtained if the fans discharge into large ducts which are carried vertically some distance above the eaves. If such vertical ducts are taken high enough the action of the wind tends to assist the extraction of air rather than to hinder it.

Extraction fans are often used to ventilate single-storey factories of small or medium size. Sometimes no suitable provision is made for the entry of air, and the incoming air enters by any available openings or crevices thus creating unpleasant draughts. Care should be taken that proper inlets are provided in positions such that a thorough scavenging of the air of the factory is ensured. Windows and other apertures near the fans should be kept closed, for if they are open the fans will draw their air supply from them and this short-circuiting will prevent efficient ventilation. Such short-circuiting often occurs. It is not uncommon to find that in a single-storey factory exhaust fans are placed at intervals in the gables, while intermediately there are louvred openings in other

gables. The fans whirr merrily around, taking their air supply from the near-by louvres, and the workers below are scarcely one whit the better for it.

Plenum Ventilation

Modern plenum installations, by which air is propelled into the building, afford some advantages over extraction systems. The temperature of the entering air can be controlled, the air can be discharged where it is required, so that even in a large building fresh air can be equally distributed, the air can be filtered or washed as it is taken in, and the slight positive pressure set up by the system prevents the inward leakage of cold air that so often evokes complaints of draughts where extraction systems are employed. The design of a plenum ventilating system is a matter for the expert engineer, since careful computation of duct sizes, fan power and heating load are required. Not least in importance are the situation and design of the air inlets. It sometimes happens that a ventilation system which supplies an adequate amount of fresh air is not so designed as to maintain adequate air movement, or that through faulty design or placing of fresh air inlets people are exposed to most unpleasant draughts. Occasionally it will be found that in factories with elaborate and well-controlled ventilating systems there are, here and there, inlets so placed that to stop draughts workers have stuffed them with sacking. If the velocity of the entering air is too low the atmosphere may feel dead and stagnant in spite of its purity. Excellent results can be achieved by causing the air to issue at high velocity from jets 2 or 3 inches in diameter, of the punkah-louvre type, provided that the direction of discharge is such that nobody works in the line of draught. The turbulence set up by these jets gives the variable air movement that helps to provide an invigorating environment. In many buildings with restricted headroom such jet ventilation is not easy to contrive. In such rooms conical or concentric-ring deflectors fitted at air inlets can be used to ensure turbulent air movement without undue draughts.

In the older plenum installations the air was driven into the building and allowed to find its way out through any available openings, but nowadays plenum and extraction ventilation are often combined, largely in the interests of economy of heating. It is generally arranged that the plenum fans supply rather more air than is dealt with by the exhaust fans, so that a slight positive pressure is maintained. Such a balanced system is commonly used in air conditioning.

Air Conditioning

By air conditioning is meant the complete control of the purity, temperature, humidity and cleanliness of the air. It is a combination of ventilation with heating or cooling, and with modern equipment any desired condition of temperature or humidity can be maintained. In some industries, where the processes call for controlled temperature and humidity, or where exceptionally clean air is required, air conditioning is worth while on the score of increased efficiency. But in the climate of this country factory buildings can usually be suitably ventilated by methods which are less costly than full-scale air conditioning, and, in fact, when industrial buildings are air conditioned it is almost invariably for the benefit of the product and not of the worker.

V. Methods of Warming

Heating methods used in buildings are divisible into two groups according as the heat is transmitted mainly by convection or by radiation. In convective warming the air is heated and the structure and contents of the building are warmed by contact with the heated air. With radiant heating, on the other hand, the radiation warms those surfaces on which it impinges, and the air is warmed by contact with those surfaces. Thus, in the case of the familiar open fire, the walls and furniture become warmed by the radiation from the fire and then in their turn impart heat to the air. The chimney breast becomes warmed by the passage of the hot gases up the flue, and that in turn warms the air of the room by convection. At some points in such a room the average intensity of radiation from all directions is such that the mean radiant temperature (or mean temperature of the solid surroundings) is rather higher than the air temperature.

With convection heating, as with so-called hot-water radiators or steam pipes, or, more especially, when warming is by the circulation of heated air, the mean temperature of the surroundings is below the temperature of the air. In some buildings this defect of air temperature below mean radiant temperature is only 3° or 4° F. during cold weather, but in thin-walled and thin-roofed structures which are poorly insulated the difference may be much more. As has been remarked earlier, it is undesirable that the temperature of the air should be much above that of the surroundings, and in such cases as those instanced the convective heating should be supplemented with some radiant heat.

Hot air tends to rise, and because of this some methods of air warming produce the undesirable condition in which the air at head level is considerably warmer than that near the floor. Such a condition causes feelings of oppression and stuffiness in the head, while the feet are cold. These temperature gradients are not only a potent source of discomfort; they are wasteful of heat, for the pooling of hot air near the ceiling or in the roof space increases the heat loss from the building. In some factories heating is by steam or hot-water pipes suspended 10 or 12 feet above the floor. The air heated by these pipes rises and tends to pool at the higher levels, and steep temperature gradients are common with this method of heating. If the heat must be supplied in this way, much discomfort could be avoided by arranging that the hot air above the pipes is dispersed by fans and thorough mixing thus

achieved. Some installations in which hot air is circulated also produce unpleasant temperature gradients. This is especially liable to happen if the fan system discharges a relatively small volume of air heated to a high temperature. It can be stated as a general rule that any air-heating system, whether it be for heating only or for combined heating and ventilation, should discharge a large volume of relatively cool air rather than a small volume of much hotter air. There is much to be said in favour of the modern tendency to supply air at approximately the temperature which it is desired to maintain in the room, and to use radiant heating to compensate for the heat losses from the structure.

Provided that these two important faults, steep temperature gradients and cold walls, etc., are guarded against or compensated for, almost any method of heating can satisfactorily be used to maintain a suitable temperature, so long as the temperature can be kept reasonably uniform throughout the workroom.

In narrow buildings, hot-water pipes or radiators placed along the walls near floor level give excellent results, and with adequate ventilation they produce only slight temperature gradients. Such heating appliances placed higher on the walls, say at head level, cause appreciable gradients of temperature, and are undesirable.

In extensive single-storey buildings unit heaters have been much used in recent years. A unit heater comprises a fan of the open-blade or propeller type, housed usually in a rectangular casing which also contains a heating battery. The fan passes air over the heater and thence propels it through a louvred outlet into the room. The direction of discharge can be altered by adjusting the pitch of the louvres. These heaters possess the advantage that they can be slung from the roof members where desired, and thus they are out of the way of machinery and do not hinder the transit of materials. They are primarily intended merely as a means of heating by warming and recirculating the air within the building. If, however, a short duct is fitted to the intake side of the unit heater it can be made to take fresh air from outside, and it thus becomes a valuable ventilator also. The incorporation of a simple baffle arrangement makes it possible to handle fresh and recirculated air in any desired proportions. Obviously, when the heater is thus connected to the outer air it can be used to impel cool air into the building during summer. If unit heaters are to give satisfaction they should not be run at too high a temperature. They should be installed in sufficient numbers to ensure that overheating of the air will be unnecessary. Properly installed and used these units create beneficial air movement, and maintain pleasant working conditions, but if overrun they may cause dissatisfaction.

Radiant heating may be from low-temperature or high-temperature sources. An example of the former group is the panel-heating that is now frequently used in office buildings, and less often in factories. In some cases hot-water pipes are embedded in the ceiling, so that a large proportion of the ceiling area is warmed to about 100° F. This warmed surface radiates heat downwards and the contents of the room are thereby warmed. There is often some leakage of heat through the floors above, so that the floor also acts as a mild heating surface. Another form of low-temperature panel heating is that in which heated metal plates form part of the wall surface. These wall panels are also effective warming agents. Panel heating causes no appreciable temperature gradients (Vernon, Vernon, and Lorrain-Smith, 1928).

Another system of panel heating consists in the use of small medium- or high-temperature panels heated by electricity. They are about 2 ft. by 1 ft. in area, and are heated to approximately 500° F. They are hung in inclined positions so that they radiate across the room in a downward direction. By suitable placing it can be arranged that they give a sensible amount of radiant heat at any position in the room. Unless the room is very lofty they should not be placed horizontally, for the full radiation from such a source when the head is only perhaps 4 feet away is very unpleasant.

Some years ago there was a tendency to use flueless gas heaters in many situations. There was said to be no risk of untoward effects accruing from their use. It should be remembered, however, that these appliances are not always kept in perfect condition, and the possibility that undesirable results may arise from the escape of carbon monoxide, or of sulphur compounds, should be borne in mind.

VI. Thermal Insulation

Cold walls tend to make a room seem chilly even when the air temperature is such as would ordinarily be found comfortable. Good thermal insulation of the walls and roof not only reduces the loss of heat from a building, but also raises the temperature of the internal wall surface. Thus, good insulation enhances comfort and effects economy of fuel. As Pallot (1943) says, the subject of thermal insulation has not in the past received the attention it deserves. Pallot gives a thorough discussion of the principles of thermal insulation, and instructive examples are contained in *Fuel Efficiency Bulletin*, No. 12, issued by the Ministry of Fuel and Power. Insulation of thin roofs helps to exclude solar heat, and thus reduce internal temperatures in summer. If the outer roof surface is whitewashed, or otherwise coated with white material, a substantial part of the sun's radiation will be reflected.

In some industries shop temperatures are often needlessly high owing to the heat given off by hot machines or other plant. Great relief to the workers could, in many cases, be obtained by careful insulation of such plant.

VII. Supervision

In many factories it is nobody's special business to see that proper use is made of such means of heating and ventilation as are provided. Some member or members of the staff should be charged

with the duty of supervision. Thereby much discomfort would be obviated, and in many cases the loss of efficiency consequent on overheating would be avoided.

Acknowledgments

Thanks are due to Cambridge University Press for permission to reproduce fig. 2 from the *Journal of Hygiene*, and to the Institution of Heating and Ventilating Engineers for permission to reproduce fig. 3. Fig. 4 is redrawn from Rept. No. 76 of the Industrial Health Research Board, figs. 6 and 7 are reproduced from Industrial Fatigue Research Board, Rept. No. 35 by permission of the Controller of H.M. Stationery Office. The effective temperature chart (fig. 5) is given by courtesy of the American Society of Heating and Ventilating Engineers.

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NUTRITION AND THE INDUSTRIAL WORKER

BY

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The subject of nutrition is so vast that it has become impossible for anyone with wide other interests like a medical officer in industry to follow in detail all its ramifications and rapid developments. It is essential, however, that he has an accurate knowledge of the fundamentals.

It is well known that a defective diet will lead to inefficiency and diminished energy as well as deterioration in health and structural changes in the body, just as—for analogy—poor petrol and oil will lead to a bad performance followed by wear and tear and damage to a motor car. This necessity for correct and adequate feeding of industrial workers has been reflected in the Factories (Canteen) Order, 1943, which requires the provision of a canteen in all factories employing more than 250 persons.

The Industrial Medical Officer is interested not only in maintaining health, in the sense of preventing disease, but particularly also in maintaining the maximum working efficiency of the employee. For this reason he must have a knowledge of the bodily requirements, the evidences of malnutrition, especially in minor degrees, and must also have some practical ideas on how to control or improve the dietary of the workers. He must be able to detect malnutrition in new employees and estimate its effects on working ability and the prospects of a cure. He must be able to detect malnutrition arising amongst employees and to determine the factor responsible for it, and he must be in a position to give the management and the canteen manager advice on the quantity, quality and frequency of meals provided for the workers. Also he may have to educate the workers by publicity and personal instruction.

It is proposed, therefore, to go briefly through the main factors necessary to a satisfactory diet and to mention some of the effects of deficiencies. In general these will be confined to the effects of minor deficiency as the effects of major defects are less commonly seen in this country and also are comparatively well known. Lastly, some of the causes of malnutrition will be considered and a few of the problems facing industry will be discussed.

The main constituents of a diet are the following:

1. Water.
2. The energy value (measured in calories).
3. Carbohydrate.
4. Fat.
5. Protein.
6. Salts.
7. Vitamins.

Water is obviously an important part of a diet. It is probable that minor variations do not affect health and it is difficult to state an optimum requirement as this varies with climatic and other conditions. The Factories Act requires a supply of wholesome drinking water at suitable points in the factory. In the case of hot processes when the amount of fluid taken is considerable, attention should be given to the form of fluid, as the habitual ones, tea, beer or barley water, are not always desirable. A suitable saline drink, as mentioned again later, is probably the best.

Energy Value or Calories. The body burns foodstuffs to provide energy, chiefly carbohydrate, fat and protein, but also small amounts of other substances such as alcohol. A certain amount is required for vital processes such as respiration, the circulation and keeping the body warm. This is the basal metabolism and is approximately proportional to the surface area of the body—about 920 calories per square metre. It falls slightly with age. For an adult it usually lies between 1200 and 2000 calories a day, depending on size.

Over and above this, energy is required for work and other activities. The body as a machine compares well with most engines, but even so, is less than 20 per cent. efficient; 5 calories of food eaten produce less than 1 calorie of mechanical energy. Neither is food a cheap fuel. It costs about ten times as much to get mechanical energy from food as from petrol. Or as another example, one unit of electricity costing less than one penny corresponds to 860 calories of which 95 per cent. or more may be converted to mechanical energy. To provide this much mechanical energy from the human body requires more than 4000 calories of food, costing probably twenty times as much. It is thus very expensive to waste human effort and all possible processes should be mechanized.

The calorie requirements of the body vary enormously with different types of work. For example:

Sitting at rest	..	requires 30	calories	per hour
Standing at rest	..	,, 40	,,	,,
Sweeping the floor	..	,, 100	,,	,,
Walking about	..	,, 200	,,	,,
Running	.. ..	,, 500	,,	,,
Boxing	.. ..	,, 800	,,	,,

To generalize one can say light work 50–75, moderate work 75–150, hard work 150–300 and very heavy work 300 or more calories an hour.

From tables such as this calorie requirements of an individual can be fairly accurately worked out. For our purpose this is not necessary and it is usually enough to allow 2400 calories daily for light, sedentary work, 3000–3500 for moderately hard work, rising to 4000 or 4500 for very heavy work.

If a diet is insufficient the weight falls, there is weakness and fatigue and the person feels the cold more than before. After a time the body learns to use food more economically and also bodily movements are economized.

In most cases of starvation other dietary deficiencies will be present as well, showing their characteristic signs and symptoms. When the carbohydrate and fat resources of the body have been used up the body lives on its proteins. This has been suggested as the reason for the lowered resistance to some infections such as tuberculosis.

The provision of an adequate amount of food for energy must always be the first consideration in planning a diet.

Carbohydrate. Carbohydrates supply in a normal diet a very considerable part of the energy requirements of the body. The more complex carbohydrates are broken down to glucose in the intestine before absorption and the glucose then circulates in the blood from which it can either be used directly by the muscles or stored as glycogen in the liver.

Glucose is thus far the most easily assimilable food. There is some evidence that 2–2½ hours after a meal the blood sugar falls with feelings of fatigue. This tends to be compensated later by an output from the liver. Some athletes claim that glucose taken before a contest improves their performance.

There is often a tendency to condemn carbohydrates. There is good reason to believe that carbohydrates are burned as such by the muscles and that work is done most economically when carbohydrate is the fuel. Provided the other essential dietary factors are adequate the further calorie needs can well be met by carbohydrate.

Fat. Fat is a compact form of energy providing food, one gram being equal to about two of carbohydrate or protein. It is quite probable that fat is not a necessary constituent of a diet as the body can make it out of carbohydrate, though it is possible that it is a necessary vehicle for some of the fat-soluble vitamins. Vitamin A can be produced from the precursor carotene present in vegetables, and vitamin D is formed in the skin by the action of ultra-violet light. Vitamins E and K are found in vegetables, and vitamin K is apparently produced in the intestinal tract by the action of certain bacteria, so an outside source may be unnecessary. Two fatty acids—linoleic and linolenic have been found necessary for the health of rats, an absence leading to the development of a skin disease. There is so far no evidence that these fatty acids are necessary for the human, though some vendors of protective skin creams have seized upon it and include linseed oil in their product, together with very exaggerated claims of its merits.

It is probably desirable in the present state of our knowledge to include a certain amount of fat in the diet because of its high calorie value and because of the fat-soluble vitamins. Because the body can obtain the latter by other means it does not necessarily follow that it is always able to do so or to do so in sufficient amounts.

Protein. Proteins are complex organic compounds composed of chains of amino acids. During digestion they are broken down into the separate amino acids and as such absorbed into the body. The body then builds its own protein and probably other substances as well, from these amino acids. The body can apparently synthesize some of the amino acids, but not all. Of the 22 known, 10 are thought to be incapable of synthesis and must be present in the food taken.

Some food contains all or most of these essential amino acids—especially meat, milk and eggs, and comparatively little will supply the needs of the body. These are known as first-class proteins. Others, such as vegetable protein, contain little or none of some of the essential amino acids and hence may only supply bodily needs if taken in large quantities or may not be able to supply them at all. These are known as second-class proteins

Protein is required for the formation of living cells for growth, wear and tear, secretions—milk, mucus, etc., the formation of enzymes, hormones, etc. In addition to the daily intake there is a considerable store of body protein—where is not known for certain, but probably a good deal in the liver.

Protein can be used as fuel, having the same calorie value as carbohydrate, and it is obvious unwanted amino acids must be so used, even on a low protein diet.

Protein requirements are highest during growth and pregnancy, but are also high in alimentary or other diseases in which absorption is defective, and in nephritis, nephrosis, serous effusions, fevers, etc., in which there is excessive loss or destruction of protein.

Total calorie intake has a very important bearing on the protein requirements of the body. With a high calorie diet the protein requirements of an adult can be reduced to quite a low level. If the diet is low in total calories the body has to fall back on the protein to use as fuel, leading to a relative protein deficiency. This is the explanation of most cases of protein deficiency that arise. In almost all cases the total diet is very inadequate.

A normal adult requires 80–100 gm. a day, of which at least one-third should be first-class protein. One-and-a-half times this amount is required during pregnancy, lactation and for growth between 14 and

20 years of age. The effects of deficiency of specific amino acids are not known for certain in the human. The effect of a total deficiency is the production of oedema—famine oedema or nutritional oedema, and like all these things is frequently associated with other nutritional deficiencies.

The symptoms and signs are fatigue, weakness, lessened growth and oedema. Borderline cases may only show oedema after excessive standing, exercise, drinking large quantities of fluid, an excess of salt, getting too hot or other precipitating cause.

It seems probable that some of the cases of oedema we label idiopathic, or postural or Milroys disease may well be nutritional. Confirmation of the diagnosis can be made by a study of the diet and estimation of the blood protein. (Normal serum protein figures total 6–8 gm. per 100 c.c., albumin 4–5·5 gm. per 100 c.c., globulin 1·4–3 gm. per 100 c.c.) In protein deficiency a reduction of the albumin is particularly significant.

Salts. Although many different salts are important in nutrition the ones that interest us most are sodium, iron and calcium.

Sodium is present in adequate amounts in most diets. Its interest to the industrial medical officer is that workers in hot processes, such as stokers and tinplate workers, lose large quantities of sodium chloride in their sweat, giving rise to weakness, fatigue and cramp in the limbs. Men on these jobs must be provided with plenty of fluid, not as beer or barley water, but as saline, somewhat less than normal strength.

Iron is essential for the formation of haemoglobin. In the breakdown of red cells in the body almost 80 per cent. of the iron is retained, but the other 20 per cent. is lost and must be replaced from food. In growing children and pregnancy new blood is being formed and a greater supply is needed. In women there is a greater loss than in men because of menstruation.

The daily allowance should be 15 mgm. for adult men and 20 mgm. for adult women, with more during pregnancy. This figure is for available iron. Much of the iron taken, especially that in organic combination, is not absorbed. Inorganic, ferrous iron, is absorbed best. The symptoms and signs of iron deficiency are those of anaemia, and are well known.

Iron deficiency is not, of course, the only cause of anaemia. Lack of vitamin C, as well as the many well-known diseases, can cause failure of haemoglobin formation.

It is worth remembering that the treatment of any appreciable degree of anaemia by diet alone will be very slow. An additional 5 mgm. of iron absorbed and used daily only raises the haemoglobin level of the blood by 6 per cent. in a month. Large doses of iron must therefore be given in one of the usual forms such as Pil. ferrous sulph. Diet can only be effective in prevention. Many foods with a high iron content have little available iron—such as meat and milk. Liver, kidneys, nuts, whole grain cereals and treacle are high in available iron.

During pregnancy and when there is a possible dietary iron deficiency medicinal iron should be given as a supplement. All degrees of anaemia should be fully treated to raise the blood to a high normal haemoglobin figure and to obtain good body reserves of iron.

The amount of inefficiency and ill-health caused by even small degrees of anaemia does not seem to be fully appreciated yet it can be so easily treated.

Calcium. There is more calcium in the body than any other mineral element. Most of the calcium is in the bones to which it gives strength and hardness, but a smaller amount is present in the tissues and blood where it serves a number of very essential purposes. It is necessary for the coagulation of the blood, to control neuro-muscular excitability, to control the rhythm of the heart and to control membrane permeability. Normally the body loses about ½ gm. of calcium daily, which must be replaced from the food. If not replaced the calcium will be withdrawn from the bones in an endeavour to keep the blood and tissue calcium up to normal, producing softening of the bones known as osteomalacia. The needs during growth, pregnancy and lactation are much greater.

Calcium cannot be absorbed without an adequate supply of vitamin D and no excess of calcium can make up for its lack. Neither can an excess of vitamin D make up for lack of calcium. It is, for example, useless to treat rickets with vitamin D without also giving adequate calcium. As with most nutritional requirements, some individuals excrete more than others and in some absorption is defective. Absorption of calcium is most likely to be defective in cases of serious gastro-intestinal diseases such as coeliac disease and chronic ulcerative colitis

As already stated the normal loss of calcium is 0·5 gm. daily, so that an adequate diet should contain at least 0·7 gm. daily. During pregnancy and lactation 1·5–3 gm. is required and during the years of growth 1–2 gm. daily. Foods vary in the availability of the calcium they contain. Milk is our best source, but even so 1 quart only contains 1·25 gm.

Calcium in vegetables is poorly absorbed. Diets tending to produce an alkalosis favour the retention of calcium, whereas those tending to produce acidosis tend to favour loss of calcium.

The national loaf is now fortified with calcium carbonate; 7 oz. of calcium carbonate is added to each 280-lb. sack of flour. It has been shown by Harrison and Mellanby, and McCance and Widdowson that the considerable amount of phytic acid present in national flour interferes with the absorption of calcium and for this reason the adding of calcium to the flour is desirable. Some writers disagree with this view and argue that there is no evidence of calcium deficiency in the population and that we risk the danger of an excess of calcium which may cause urinary calculi, increased blood pressure and interfere with kidney and heart functions. In any case the amount added is very small and seems unlikely to do any appreciable harm.

The relation between lead and calcium metabolism is of special industrial interest. Lead absorbed by the body is stored in the bones. Conditions favouring the deposition of calcium in the bones favour the fixing of lead in the bones, and conditions leading to decalcification such as excessive calcium loss or deficient intake or absorption mobilize lead from the bones and may precipitate an attack of lead poisoning. In the case of lead workers, therefore, it is wise policy to give a high calcium diet either as additional milk or by giving calcium lactate, and so fix some of the absorbed lead to prevent the production of symptoms. There may, of course, be occasions when it is desirable to mobilize this lead from the bones and remove it—to 'de-lead' the patient. This must be done under controlled conditions and when the patient is not working.

The Vitamins

The vitamins are a group of complex chemical substances required by the body for carrying on certain metabolic processes. Some can be made by the body itself, but others must be provided in the diet. The subject is confusing because of the multiple, undescriptive and frequently changing nomenclature. Just prior to the war over 3000 original papers on the vitamins appeared annually, so that it disconcerts even the specialists. It is proposed, therefore, to speak only of the better understood vitamins and their main practical aspects.

Vitamin A. Vitamin A is a fat soluble substance present only in animal fats. It can be formed in the body from carotene, a colouring substance present in most vegetables. Vitamin A is essential to growth and health—in particular the health and nutrition of epithelial cells and to the formation of visual purple in the retina. Its alleged anti-infective properties are probably only related to the maintenance of healthy epithelium.

Deficiency leads to atrophy of epithelial cells and conversion of more specialized epithelium to stratified epithelium. The failure to form visual purple produces night blindness. Severe degrees of deficiency lead to the disease Xerophthalmia. This disease begins with photophobia, itching and burning of the eyes and slight conjunctivitis. The eyes become dry, the conjunctiva pigmented and the cornea oedematous and infiltrated with leucocytes. This is usually followed by secondary infection with ulceration and destruction of the eye.

The lesser degrees of deficiency which interest us most lead to changes in the skin which becomes dry, rough and slaty in colour with a papular eruption due to hyperkeratosis of the hair follicles, giving a toad skin appearance. The changes start on the anterolateral surface of the arms and legs and spread over the abdomen, buttocks, back and neck. Some degree of night blindness also occurs and is probably the easiest sign to detect, and a light adaptation test is the most reliable means of determining vitamin A deficiency.

Diagnosis of vitamin A deficiency is made from a study of the diet, the clinical findings and the light adaptation test.

The normal daily requirement is about 4000 international units. The most reliable sources in food, apart from fish liver oils, are liver, egg yolk, cheese and butter. The precursor carotene is best supplied in the outer leaves of green vegetables and in carrots. There is sometimes difficulty in absorbing carotene, especially in certain diseases, or difficulty in converting it to vitamin A if absorbed. Diabetes is a case in point where carotene cannot be converted to vitamin A and in the high vegetable diets sometimes taken becomes deposited in the skin giving the well-known orange pigmentation.

Vitamin A is better given, therefore, as vitamin A and not as carotene, though as a result of the war and shortage of animal fats it may be necessary for us to rely more and more on that provided from vegetables.

Vitamin D. Vitamin D consists of a group of fat-soluble substances—activated sterols—closely related to cholesterol. It occurs in both animal and vegetable fats and in addition can be formed in the body by the action of sunlight on the skin. It is necessary for the proper absorption of calcium and phosphorus and in the formation of bone in the body. The normal body requirement is 800–1200 units daily, though some writers believe considerably less than this to be sufficient.

During growth, pregnancy and lactation, when the calcium metabolism is so much higher than at other times, the need for vitamin D is considerably greater and it is consequently at these times that deficiency most commonly becomes manifest. A deficiency during growth leads to rickets. In adults it leads to decalcification of the bones and the disease osteomalacia. Symptoms of tetany may occur in either of these diseases due to the lowered blood calcium. Osteomalacia seldom occurs except during pregnancy and then is rare except in famines.

The best sources of supply are fish liver oils, egg yolk, salmon, sardines, butter and cream. The ordinary adult can get an adequate supply by a reasonable amount of sunlight and it seems that at present we need not worry much about a possible deficiency except during growth, pregnancy and lactation.

Vitamin C. Ascorbic acid is a water soluble substance present in most fruit and vegetables and essential to the body for health. It cannot be formed in the body and is poorly stored so that a regular daily supply is essential. It is necessary for the formation of intercellular ground substance and especially for the maintenance of intact blood vessels and the formation of collagen.

Advanced deficiency of ascorbic acid produces the well-known disease of scurvy with weakness, pains in the limbs, haemorrhage and stomatitis.

The less serious degrees of deficiency which interest us more are less definite in their picture, but can lead to a considerable amount of reduced efficiency and minor ill-health. The symptoms pro-

duced include fatigue, anaemia, slight oedema, sore mouth, delayed wound healing and possibly a lowered resistance to infection.

Vitamin C deficiency can be fairly accurately estimated by the saturation test in which a large dose of ascorbic acid is given followed by estimation of the amount excreted in the urine. A person deficient in vitamin C will excrete considerably less than a person not deficient. Investigations carried out on these lines have suggested that there might be a good deal of minor deficiency in the community, especially during spring and early summer.

The normal requirements for an adult lie between 50 mgm. and 100 mgm. of ascorbic acid daily.

Our main source of ascorbic acid is fruit, potatoes and other vegetables, and during spring and early summer when fruit is not available potatoes and greens supply most. One important point to remember is the ease with which it is destroyed or lost. Prolonged cooking destroys vitamin C. Prolonged soaking washes it out and it is usually thrown down the drain. Vegetables should therefore be covered with the minimum of water and this water not wasted. Also ascorbic acid is much more stable in acids than in alkalis and the use of cooking soda is therefore detrimental.

Bearing these points in mind and with the supplies at present available there should be no difficulty in providing a diet adequate in vitamin C.

The Vitamin B Complex

What was once known as vitamin B has since 1926 been split up into well over a dozen different substances having different names and actions. I propose only to mention the three better understood fractions—vitamin B_1, ribo-flavine and nicotinic acid.

Vitamin B_1. Vitamin B_1, Aneurin or Thiamin is a water-soluble substance easily destroyed by heat. It is poorly stored by the body and the body is unable to make it itself. It is essential to the body for carbohydrate metabolism so that the amount required depends on the amount of carbohydrate in the diet. It is also necessary for maintenance of normal nerves, appetite and digestion, circulation and growth.

Serious deficiency leads to the disease beriberi with peripheral neuritis, oedema and heart failure. The manifestation of less severe degrees of deficiency are fatigue on slight exertion, loss of appetite, tenderness of the calves and later progressive weakness, nausea, vomiting and tachycardia. These symptoms, like those of other vitamin deficiencies, are not very characteristic, but they have been determined by careful experiment and respond very rapidly to treatment with vitamin B_1.

The best dietary sources are meat, liver, the germ of cereals, peas, beans and yeast. The normal daily requirements may be taken as 1–3 mgm. or 300–900 international units, though the requirements, of course, are related to the carbohydrate in the diet. It has been found that beriberi only occurs if the ratio B_1 (units)/non-fat calories in diet is less than 0·12.

The diagnosis of B_1 deficiency will depend on the clinical picture, diet history and a therapeutic test.

Riboflavine (Vitamin B_2 or G). Riboflavine is a water-soluble, heat-resistant substance first isolated in 1932, although the clinical picture of the deficiency syndrome was not described until 1938. It appears to be essential for carbohydrate metabolism, for normal growth and for the health of epithelial issue.

Riboflavine deficiency gives rise to the following clinical manifestations. First cheilosis—or angular stomatitis—in which the angles of the mouth develop bilateral transverse fissures, a condition we previously knew as perleche. The lips themselves become abnormally red and shiny due to superficial denudation of the epithelium and later cracked and crusted with blood. In addition to cheilosis the skin shows changes resembling seborrhoeic dermatitis with a scaly, greasy desquamation of the naso labial folds, which later may involve the alae nasi, bridge of nose, eyebrows, ears and other parts of the body. Besides these changes the eyes show vascularization of the cornea and conjunctival congestion. The first sign is circum corneal injection which, if not visible to the naked eye, is visible with a slit lamp and shows vessels beginning to invade the cornea.

Riboflavine is widely distributed in foodstuffs, but amongst the best sources are yeast, milk, eggs, fish roe, kidney, liver, heart and growing leafy vegetables.

The normal daily requirements are not yet accurately known but 1–2 mgm. is suggested.

Nicotinic Acid. Nicotinic acid is a water soluble heat-stable vitamin, related chemically, but not pharmacologically to nicotine. It is essential to the body for growth and for health of epithelial and nervous tissue. Like vitamin B_1 and riboflavine it appears to be necessary for carbohydrate metabolism.

Gross deficiency causes pellagra, a disease characterized by a sore tongue, dermatitis and mental changes leading to insanity.

Minor degrees of deficiency are probably not uncommon. The symptoms are ill-defined and include abdominal pains, indigestion, lassitude and nervous and mental depression. A sore mouth and tongue is one of the commonest symptoms. The tongue shows first a marginal atrophy and later becomes red raw and glazed. Infection with Vincents angina is common and it has been suggested that Vincents angina can only attack tissues weakened by nicotinic acid deficiency.

The nervous symptoms are important to remember as it seems quite possible that this may be the explanation of many of the vague cases of depression. debility, and doubtful psychoneurosis we see.

At present the diagnosis must rest mainly on symptomatology, diet history and on therapeutic tests. Therapeutic tests are very easily applied and the response very rapid.

Nicotinic acid, like other components of the B complex, is widely distributed in food, particularly

in meat products such as liver, eggs, salmon and in whole cereals and yeast.

The probable daily requirement is about 20–50 mgm.

Of the other vitamins which have been and are being discovered it is not proposed to say anything except that if we keep to a good mixed diet, adequate to provide the ones mentioned, it is improbable that the others will be grossly deficient.

Should evidence of malnutrition appear in a community the factors responsible will probably be found under one of the following main headings:

1. Insufficient food available—insufficient variety or faulty distribution. Poverty—insufficient money to buy the food.
2. Faulty likes and habits of the people. This is closely linked with what shops sell, canteen and restaurants provide and publicity in and out of the factory. Also legislation—e.g. national bread.
3. Faulty cooking, preparation and treatment of the food.
4. Diseases and abnormalities of absorption in the individual.

Are there nutritional deficiencies occurring in this country now and, if not, are there prospects of them arising? It would take too long to discuss all the arguments for and against these points now, but it seems safe to say that, except in special cases such as badly fed institutions, and in people with deficiencies of absorption or other predisposing disease, the gross deficiency diseases do not occur. There does seem, however, to be evidence of much minor malnutrition—not necessarily worse than in pre-war days—but sufficient and sufficiently widespread to be a cause of much minor ill-health and loss of efficiency. There may be many and real difficulties in giving a fully optimum diet to all in war time, but there is no doubt that by careful distribution, the provision of sensible meals, and most of all the education of workpeople and others in correct habits of diet, likes and dislikes, cooking, etc., much improvement can be made. It must, of course, be emphasized that malnutrition is not the cause of all minor ill-health—probably only of a small part. All the other factors—fatigue, ventilation, exercise, psychological considerations—must still be given their proper attention.

In addition to these considerations certain practical aspects of the problem of feeding workpeople arise.

The first is what meals and at what frequency should meals be provided at the factory? It would seem probable that a meal or snack every 2½ or 3 hours is the most desirable. This should help to maintain efficiency by preventing a fall in blood sugar which may occur several hours after a meal, and it might help also to reduce the incidence of peptic ulcer which is at present very high and a cause of much disability and absenteeism. It is suggested, therefore, that facilities should be available for obtaining (1) breakfast for those who have a long journey to work ; (2) a mid-morning snack; (3) a midday full meal; (4) an afternoon snack or tea; (5) an evening meal for those with long travelling or not wishing to go straight home. Equivalent arrangements for feeding night workers should be arranged. Many night workers, especially those on alternating day and night shifts, take normal daytime meals and very little food during the working hours. They should be encouraged to eat during the working hours and sleep in the day, and good canteen facilities will be an incentive to do so.

The food value of the meals provided is of some importance. Inasmuch as the midday meal is the main meal of the day for most people it should provide 1000–1500 calories, two-thirds or more of the vitamin and mineral salt requirements and a considerable proportion—at least one-third—of the protein requirements. This is the standard aimed at by British restaurants. Whilst it might be desirable to have some of these factors more evenly distributed over the other meals, one must remember that it is the habit of many to have bread and butter, bread and lard or bread and margarine as almost their only other food. Other canteen meals may be mainly calorie producing, though opportunity should be taken to introduce vitamins, salts and proteins when possible.

The canteen should also aim at providing special diets for certain persons suffering from diseases such as peptic ulcer, diabetes and cholecystitis. Special consideration should be given to the meals available for juveniles in view of their high requirements of protein, calcium, iron and vitamins, and if possible they should be provided free or cheaply.

In addition to providing sound meals it will be found necessary to encourage people to use the canteen. To do this the meals must be cheap, well cooked, soundly chosen and attractive, and the canteen conditions must be pleasant and comfortable. Publicity on the principles of sound nutrition should also be undertaken by the normal channels of posters, pamphlets and lectures, and individual instruction when occasion arises should be given by the nurse or medical officer.

The medical officer should co-operate with the canteen manager in arranging the type and frequency of meals provided and may help in the construction of menus, both for normal and special diets. He should also keep him acquainted with the latest developments in nutrition, including certain scientific aspects of cooking.

In conclusion, let it be said that many difficulties stand in the way of fully applying the scientific principles of nutrition, chief of which are old-standing habits and tradition. Progress will at the best be slow and patient education of the workers themselves, the factory management and the canteen staff will be necessary if results are to be obtained.

SOME FOOT FAULTS RELATED TO FORM AND FUNCTION *

BY

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It is not proposed to discuss frankly deformed feet, but the apparently normal foot which aches and swells, causing its owner much misery. For the problem, which remains unsolved for far too many doctors, is—Why does a good foot break down under the stress of exercise or work? And what should be done to prevent and to cure foot fatigue, muscle spasm or stiffness of joints which are not diseased?

In the foot fatigue cases, the symptoms are almost exclusively those of fatigue of muscles. Because the symptoms are muscular and because it is easy to study the physiology and anatomy of muscles, and because a great deal of research work has been done on postural and contractural tonus, on reflex inhibition and augmentation of tonus, on reciprocal innervation and many similar matters, there has been a tendency, in the case of the foot, to confuse cause and effect, and to ascribe to the muscles primary functions which belong to other structures. There is no constant relationship between shape and symptoms. You may see an apparently normal foot associated with much aching and fatigue and immediately afterwards a badly deformed one which gives rise to few or no symptoms.

We have to study, therefore, those structural factors which give rise to or are capable of causing muscle over-work. The understanding of foot strain rests on a knowledge of such factors. The central theme of this paper is an analysis of the way in which they cause muscle fatigue. But we must remember also that the foot is a small thing, into which are packed many important components of small and even minute size. An abnormality, therefore, may be—indeed usually is—not a glaring and gross entity, but something which needs a very critical eye or delicate finger to detect. The orthopaedic surgeon must learn to regard as important small changes of shape, structure and movement in the foot.

There is also that lamentable habit, to which we all fall victims at times, of attributing to every joint and ligament the characteristics of one particular joint or ligament. We know that there are mobile, semi-mobile and immobile joints in the body; that there are non-weight-bearing joints in the upper limb and weight-bearing joints in the lower limb, and so on. In many diseases we have come to realize that each individual joint reacts in a different manner. Similarly we must not think of the foot and its joints as having the same reactions to stress and strain as a joint such as the sacro-iliac or the elbow.

In order to understand the faults we must study the anatomy and physiology of the normal, namely, (1) the structure of the *foot-unit*, (2) its shape, (3) the universal joint between it and the leg, and (4) the actions of the muscles. Much of orthopaedic surgery is concerned with posture and the position and control of joints, and so there has arisen an Orthopaedic concept of the foot.

The Orthopaedic Concept of the Foot

The rise of this concept is due to the work of Norman Lake and Lambrinudi in Great Britain and of D. J. Morton, Dickson and Diveley in the U.S.A. Like so much in present-day surgery of the limbs, it is the result of careful observation, scientific tests and applied mechanical or engineering principles. It states that the foot is a resilient shock-absorbing unit, attached to the leg by a universal joint in such a way that it is in equilibrium with, or squarely placed on, the ground, and capable of acting as a base or plinth, on which the leg can be maintained in an upright or in an inclined attitude under all but exceptional circumstances.

A resumé of the essential anatomy and physiology may be stated as follows. The foot-unit, as will be seen in fig. 1, is an inherently strong resilient domed structure. The talus is not a part of the skeleton of the foot-unit, but of the universal joint (*q.v.*). The British have laid stress on the rôle of the muscles to the exclusion of the ligaments of the foot. There is much evidence that this is incorrect. Ballet dancers' feet, for instance, are said to go 'flat' when in the position of rest with relaxed muscles. But, as will be seen in the case illustrated in fig. 2, there is no sign of 'flatness.' Further, observations on babies, whose ages range from fourteen days down to twelve hours, demonstrate that the arch is

* Condensed from an illustrated lecture at Manchester University on the 23rd May, 1943, and at Bristol University on the 11th July, 1943.

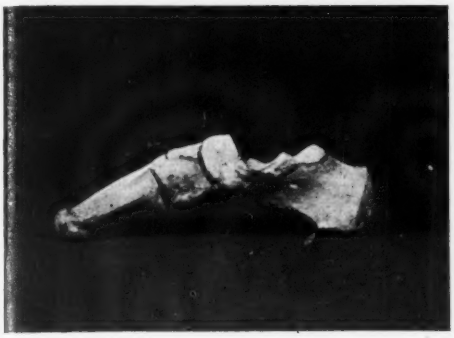


FIG. 1.—The skeleton of the foot-unit showing its domed shape.

FIG. 2.—With the camouflage of the ballet shoe removed the ballet-dancer's foot is anything but flat.

present long before the muscles could cause it to arise, and a girl with a completely paralysed foot and leg below the knee has been shown to possess a beautifully domed foot at rest and when weight-bearing. Lastly, there is Norman Lake's experiment with a freshly amputated leg. Here the leg is placed upright in a stand and weights are piled on it. The muscles are stripped and the various ligaments are divided in turn. X-rays confirm the naked-eye evidence that it is not until every ligament on the plantar aspect and between the bones have been cut that the foot goes flat. Of more importance is the fact that as soon as the spring ligament is divided, the foot-unit starts to pronate. The inner border commences to become convex, as well as to sag, because the combined action of eversion of the foot and of inward rolling or rotation of the tibia, fibula and talus allow it to overbalance or overturn at the subtaloid portion of the universal joint. The movement can be further demonstrated in dealing with the universal joint by means of the articulated skeleton. The point is important because a true flat foot is rare. Nearly all the so-called flat feet are pronated or overturned feet. This is dealt with more fully under the section Pronated Foot. The *foot-unit* remains in equilibrium on the ground because of its shape, which is either a tripod or hexapod or like an outrigger canoe as shown in fig. 3.

The traditional British view is that it is a tripod, the legs being the heel posteriorly and the first and fifth metatarsal heads at inner and outer side respec-

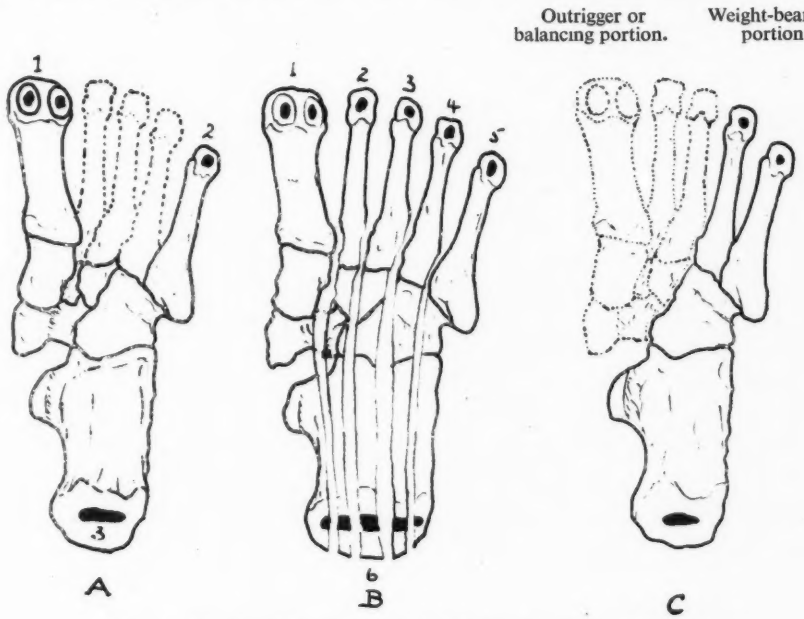
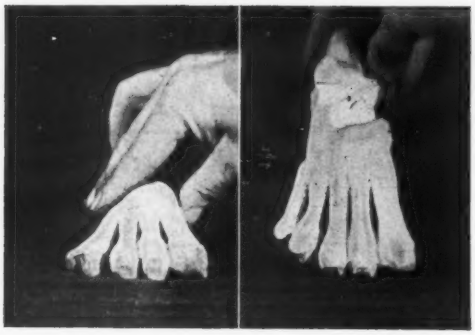


FIG. 3.—The three views as to the weight-bearing properties of the foot unit.
(A) Tripod. (B) Hexapod. (C) 'Balanced-line.'

tively of the front of the foot. D. J. Morton showed that all five metatarsals transmit weight in the proportion two units for the first and one unit each for the other four. M. A. MacConail of Sheffield claims that the outer part of the foot—the os calcis, cuboid and fourth and fifth metatarsals—transmits weight, while the scaphoid, cuneiforms and inner three metatarsals are the balancing portion and act



A B

FIG. 4.—The equilibrium provided by metatarsal width.
(A) Wide and stable when bare-footed.
(B) Narrow and unstable with high heels.

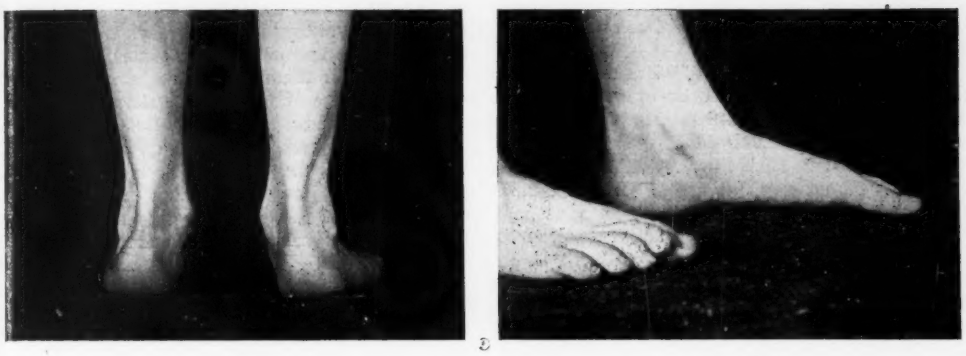
in the same way as the outrigger of a Pacific canoe. It is obvious that, whichever hypothesis be correct, the width of the metatarsal arch and the stability of at least the first and fifth metatarsals determine the lateral balance or equilibrium of the foot-unit (see fig. 4).

The foot-unit is attached to the leg by a universal joint (see fig. 5) consisting of the ankle, which allows (up and down) movement round a transverse axis, and the joint between the talus and the rest of the foot, which allows inward and outward bending round an antero-posterior axis together with an inward and outward rotation relative to the vertical axis of the leg. While each of these three types of movement can be performed separately to some extent, it is usual for all three to be associated, so that when 'the toes are pointed' the foot not only plantar flexes, but also inverts and rotates inwards; and vice versa. In particular, inversion and eversion movements are seldom made without inward and outward rotation. When the foot is fixed to the ground and cannot rotate, inversion of the foot is associated with the complementary movement of external rotation of the leg, while eversion or pronation of the foot is accompanied by inward rotation of the leg (see fig. 9). This association of movements is very important. It explains a number of cases of so-called foot strain.

The functions of the extrinsic muscles are three. Acting from the foot to the leg, they balance the leg on the foot rather like self-adjusting guy-ropes. They stabilise or balance the foot itself by their control of the universal joint. This is probably their most important postural action. Finally, they lock the bones together into firm apposition, thus strengthening the dome. All these functions are affected by the normality or otherwise of the foot structure. Provided the structure and position of the foot are normal, and the posture of the body such that its centre of gravity is directly over the ankle joint, the muscles have a minimum of work to do. Where there are defects of structure, their work is increased. Where there is defect or abnormality of tonus due to pain, poor posture, faulty footwear, bad habits, awkward occupation and the like, their work is increased. Under these circumstances fatigue may be rapid and, therefore, foot strain, which is muscle strain, arises.

A B C

FIG. 5.—Movements taking place at the subtaloid joint.
(A) Neutral position. (B) Pure inversion. (C) Inversion associated with inward rotation of the foot around the long or vertical axis of the leg.



A B

FIG. 6.—Pronated foot.
(A) Rear view showing everted heels. (B) Heel upright ; first metatarsal head elevated, great toe plantar-flexed.

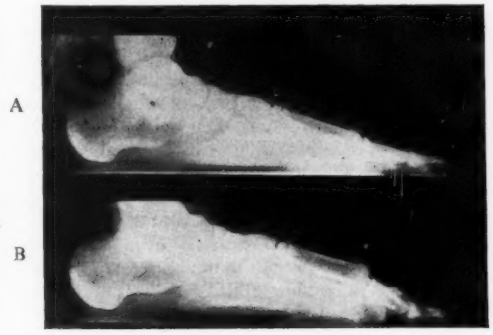
Defects of Structure and Equilibrium of Foot-Unit

Remembering that the foot may be regarded as a tripod we realize that, just as in the case of a three-legged stool, if one leg is short or at the wrong angle, the foot will tilt over or lean towards that faulty leg. The most common fault affects the first metatarsal. It may be permanently tilted upwards in comparison with the others because it has the wrong shape at its base or has been fractured, or it may be so poorly fixed by its ligaments that when weight is transmitted through it its head moves upwards (fig. 7). Lambrinudi named the former Elevated First Metatarsal or Metatarsus Primus Elevatus, and D. J. Morton calls the latter Hypermobile First Metatarsal. Sometimes the fault is that the metatarsal is too short. As the results of these conditions are similar, they are classed here together under the name of Incompetent First Metatarsal. As it is common, it is proposed to examine it in some detail because it gives the clue to so many points which must be observed in examining the foot. In examining the feet it is wise to adopt a standard position of standing. The feet should be parallel and about six inches apart.

Pronated Foot

When there is an incompetent first metatarsal, the first and obvious thing that happens is that, lacking effective support on the inner side, the foot rolls over inwards. It overbalances. The Americans call it Pronation; it is an excellent term. Nearly all cases of so-called ' flat foot ' are not flat feet, but are pronated feet. The points of diagnosis are these.

The foot looks as if it were flat. The inner border is convex and depressed from prominence of the scaphoid and head of talus. It is perfectly mobile and the individual can easily stand on the outer border of the foot, i.e. can invert or supinate. On supinating the foot, the inner side of the forefoot leaves the ground, but the hallux plantar flexes and we notice the rather large head of the elevated first metatarsal (fig. 6B). In the normal foot, supination is accompanied by dorsiflexion of the great toe. Do not be caught out by patients who have been receiving treatment in the massage department. They plantar-flex the great toe on supination because they have been taught to do so. In the pronated foot, the plantar flexion is due to the



A
B

FIG. 7.—Lateral view of x-ray of weight-bearing foot.
(A) Normal. (B) Elevated first metatarsal.
(Compare with 6B.)

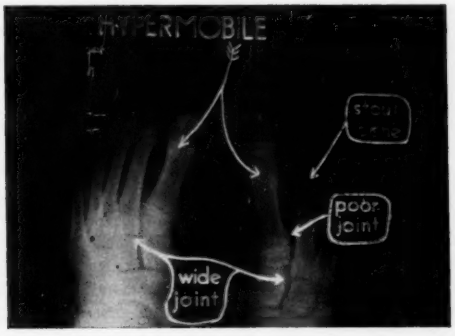


FIG. 8.—The significant points of the AP x-ray.
(See text.)

muscles making use of the hallux to support the inner border of the fore-foot in place of the incompetent first metatarsal.

Turn the patient round and look at the heel from the back; it is turned out or everted (fig. 6A). Make the patient invert or supinate till the heel is upright and look at the fore-foot again. The head of the first metatarsal is lifted off the ground and the hallux plantar-flexed (fig. 6B). It is not until the patient allows the foot to overbalance or pronate that the first metatarsal head can touch the ground. But whether pronated or supinated there is no change in the height of the 'arch.' In other words, we are dealing with a structurally abnormal foot which has no inherent stability or equilibrium. The three-legged stool with a short leg has fallen over towards the short leg, and that leads to muscle overwork.

On examining x-rays taken with the heel upright, we see in the lateral view the elevated first metatarsal, the plantar-flexed hallux and a good longitudinal arch (fig. 7). In the antero-posterior view there are several significant points (fig. 8). (a) The first metatarsal may be a little short. If very short, its shortness explains its inability to act as an efficient leg to the stool. (b) There is a very wide joint space between internal and middle cuneiform bones. (c) There is a very poor joint or else no joint at all between the bases of the first metatarsal and the second, and sometimes none between the second metatarsal and the internal cuneiform. (d) A very significant point is the diameter of the shaft of the second metatarsal. When the first metatarsal fails in its action of being a support, greater strain is thrown on to the second, and either a march fracture occurs or else it hypertrophies.

If these points in the x-rays are not found to support the clinical diagnosis, the defect is not confined to the first metatarsal segment, but affects the whole of the fore-foot, or at least the inner three metatarsals and the cuneiforms. It is then called Supinated Fore-foot because the whole fore-foot is twisted or supinated.

It may be wondered whether, if the structural defects enumerated are basic causes, the condition of pronated foot is found in early life. It is. The writer has seen many new cases each month at a school orthopaedic clinic. But it is noteworthy that the children are sent to this only because the school doctor or teacher has spotted the deformity. They have no symptoms. Incidentally, genu valgum is almost invariably accompanied by pronated feet.

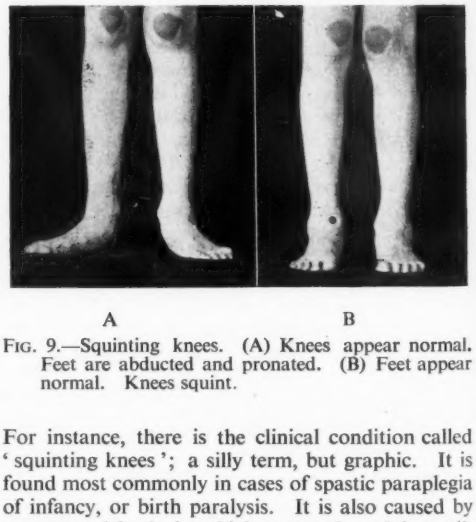
Onset of Symptoms

Then why are there no symptoms in childhood? Why do fatigue symptoms arise later in life? It is because the early symptoms are due to muscle fatigue that, in the past, it has been usual to ascribe so much of foot trouble to the muscles rather than to structural defects.

The answer is that, as already stated, one action —probably the most important action—of the muscles is to control the universal joint in order to stabilize or balance the foot itself. With a foot of normal structure they have little work to do; it can be likened to someone on roller skates. When the foot structure is abnormal its state is very like that which exists when one wears ice skates. There is no inherent stability, and the muscles have to do most of the supporting or balancing. In young and healthy persons, they are capable of this compensating action. But let anything happen which reduces their power and over goes the foot. At first the muscles make strong efforts to preserve the balance so that the symptoms of muscle strain and fatigue, aching in the legs and tiredness of the feet arise. Excessive standing or walking cause them rapidly to tire, and so we find that long route marches or long hours of standing, or the debility of an illness, or increased body-weight, or distorted shoes give rise to symptoms without there being any apparent deformity. In a sentence—the demands made on the muscles determine symptoms, and when the foot structure is poor the muscles have only a small reserve of strength with which to meet new or extra demands.

Squinting Knees

The next point for which to search is anything which alters the normal rotation of the whole leg.



A B

FIG. 9.—Squinting knees. (A) Knees appear normal. Feet are abducted and pronated. (B) Feet appear normal. Knees squint.

For instance, there is the clinical condition called 'squinting knees'; a silly term, but graphic. It is found most commonly in cases of spastic paraplegia of infancy, or birth paralysis. It is also caused by exaggerated lordosis, which causes the pelvis to tilt forwards; owing to altered muscle tonus the legs turn inwards.

Internal rotation of the leg means that the toes are turned in—'pigeon-toed.' But that is ugly and the parents, doctor and school teacher make the child's life a misery until he 'learns to walk properly.' To do that, i.e. to turn out his toes without turning his hips, he has to make use of the universal joint. As has already been seen, he can turn out his feet only if at the same time he pronates them (fig. 9). Consequently, when the lad with

squinting knees does 'learn to walk properly' he pronates. Then he is sent for treatment of so-called flat foot.

Muscle Length

An interesting group of cases is that where there is alteration of the length of muscles. The tendo achillis is often much too short or tight so that the individual cannot dorsiflex the ankle sufficiently to allow easy walking. Whereas the normal range of dorsiflexion should be some 20 to 40 degrees, in these cases it is much less. It must be tested with the knee straight, for Bohler showed that there is a gain of about half an inch by flexing the knee. When the foot will not go above a right angle, it is yet found that the patient can walk. But he does it by pronating the foot. We may test the range by holding the heel upright and by pressing on the sole. If we allow the heel to evert, i.e. let the foot pronate, we find that we can get another 10 to 15 degrees of apparent dorsiflexion. This then is the reason why the foot pronates. The powerful tendo achillis will not give way, but the foot must dorsiflex and so the weaker inverting muscles submit to force and allow the ligaments to stretch. Obviously, the treatment is to ignore the foot and to attempt to stretch the tendo achillis by exercises and if that fails, to perform an operative lengthening.

In one case which would have been impossible to solve if one had no conception of the control of the universal joint, a girl of twenty gave an unprompted story in almost these words. 'She wears lace-up shoes with wide and low heels. When walking her ankle frequently "turns" (into inversion) causing pain. When wearing high-heeled shoes she never "turns her ankle" but her legs ache.' Examination showed normal feet. Her shoes wear down on the outer side, confirming her story of turning the ankle. Test of the tendo achillis revealed that it was too tight. Thus dorsiflexion was limited and the foot tended to invert in order to gain extra movement. Inverting gains extra dorsiflexion in the same way as pronation does. The tendo achillis was not very tight and, provided her muscles acted perfectly in their control of the universal joint, all was well. When one group happened to be off guard for a moment, and she failed to put her foot down squarely, the tendo achillis caused inversion and 'turned her ankle,' causing a mild sprain.

The high-heeled shoes compensated for the short muscle, but gave rise to a new set of circumstances, such as may affect anyone who wears high-heeled shoes for walking or working. It is due to the length of the metatarsals or more correctly, though more clumsily stated, the distance which each projects forwards. The shafts of the metatarsals lie in a plane corresponding to the surface of a cone, short radius posteriorly, longer radius anteriorly. Their posterior ends are a little distance from the floor. Their anterior ends touch when the foot is bare (fig. 4A). To do so it is necessary for the lengths of the middle metatarsals to be greater than the inner and outer ones for the intersection of a cone and a plane surface is a conic section. Now in high-heeled shoes the inclination of the metatarsals is increased so that, when they are vertical, only the two central, i.e. the second and third metatarsal heads, touch the floor. The metatarsal width is reduced to a very small one (fig. 4B). The foot tends to 'wobble,' the onus of balance is thrown on to the muscles, and exactly as in the case of the incompetent first metatarsal or supinated fore-foot, they are subjected to overwork, and protest by aching.

Muscle Tonus

There is yet another series of causes to be considered. Throughout the whole body there are opposing groups of muscles called agonists and antagonists. The nice balance of power between them, whether in their dynamic actions or static functions, depends on their tonus. Sherrington proved that an increase of tonus of one group caused decrease in the opposing group by means of simple and complex nervous reflex arcs. He also showed that the tonus of any particular group was affected by sensory stimuli of many kinds. The simplest was a harmful one. As regards the foot we know that a painful stimulus to the sole, such as stepping on a tack, causes withdrawal of the foot. A less painful stimulus causes increased tonus of the dorsiflexors of the ankle and the flexors of the knee and decreased tonus of the tendo achillis and the quadriceps muscles, preparing the leg for withdrawal if necessary.

Such an alteration of the tonus, i.e. of the balance of power between opposing groups, means that if the individual continues to walk or stand while the painful stimulus persists one group of muscles has to act against a reflex desire to relax, while the added stimulus of weight-bearing further increases the tonus of the group already in enhanced tonus. This conflict is found when the patient has such painful conditions as corns or a projecting nail in the shoe, and is a fruitful source of foot fatigue, i.e. of muscle strain.

Another cause for altered tonus is an abnormality of posture. When body posture is normal the centre of gravity is immediately over the hip, knee and ankle joints. The muscles stabilizing or balancing the joints are doing minimal work under such circumstances. If the individual sags or lets the spine flex and the head hang forward or if he has to work at a job requiring him to lean over a bench or tool the centre of gravity shifts forward, and to keep himself from falling forwards there has to be an increase of tonus of the tendo achillis, and a diminution of that of the anterior tibial group of muscles. As before the disturbance of the balance of power leads to muscle fatigue.

Muscle Inco-ordination

The least well-known effect of pain is muscle inco-ordination. In certain cases of painful feet from various causes, we find that the patient cannot or will not let the tips of the toes touch the floor.

Sometimes there is flexion, but in the worse cases there is extension of the interphalangeal joints and the toes are held stiffly at 20 to 30 degrees off the floor. The long extensors of the toes and the interossei are in spasm or increased tonus. So persistent is the tonus that the patients are unable to dissociate the action of the toe extensors and ankle dorsiflexors and cannot make the toes plantar-flex while dorsiflexing the ankle. The spasm starts by being protective against pain or foot fatigue from relative or absolute muscle overwork. Established spasm leads to further muscle fatigue symptoms and is very difficult to cure.

Treatment

Although I have described many ultimate causes which appear to demand radical and extensive surgical measures, it is fortunately possible in many cases to relieve symptoms by simple means.

In the past it has been usual to class foot deformities as mobile and fixed. But now we divide them into reversible and irreversible. The reversible conditions respond to what used to be called palliative measures, such as chiropody, physiotherapy and surgical alterations to shoes. The irreversible ones are those which require surgical measures or which are so severe that nothing can be done to restore the individual to full normality.

The principles which guide us in the non-operative treatment are these:

1. Where there is much pain, where swelling and spasm exist, we order rest in bed and physiotherapy, such as radiant heat, infra-red rays and effleurage massage.

2. After a few days we start non-weight-bearing exercises, deeper massage and faradic stimulation of weak muscles, and chiropody directed to the relief or removal of painful points.

3. Following this stage, and in all less severe cases, we give active exercises out of bed, faradism and re-education exercises designed to correct the faulty action of muscle groups. We supply various supporting types of surgical alterations to shoes.

4. Next we start physical training and further exercises associated with alterations to shoes which throw a deliberate progressive stress on the feet in an attempt to over-compensate by excessive muscular development.

5. Finally, real games and heavy exercises.

It is only when the ultimate cause is severe or when conservative measures fail that we resort to surgery.

Chiropody

We have already considered that any painful stimulus affects muscle tonus. Thus, if there is a tender callosity under the first metatarsal head the muscles, such as tibialis anticus, will go into increased tonus, while the tonus of peroneus longus will decrease in order that there shall be less pressure on the painful spot. In other words, the patient will put less weight on the inner side of the foot and tend to walk mostly on the outer side. It is not surprising that muscle strain symptoms arise and that later muscle spasm supervenes. Bunions, corns, hammer toes and the like have similar effects. It is in such cases that chiropodists are invaluable.

Surgical Shoes

There is little space here to expand the subject of surgical alterations to shoes and boots. But it is necessary to stress one point. In the past, the treatment of pronated or so-called ' flat foot ' by surgical shoes has consisted of wedging and elongating the inner border of the heel and wedging the inner side of the sole. In some cases the waist of the shoe was ' blocked ' or filled in by carrying the elongation right forwards to the sole. Such alterations are mechanically, anatomically and physiologically wrong. We have seen that the fault is a supination of the fore-foot relatively to the heel. If we are going to attempt to correct the deformity we must not put any wedge or patch under the first metatarsal because it elevates it; we want to depress it. If any alteration is done to the sole it should be a wedge to the outer border. A wedge of the inner border is wrong for quite other reasons. It throws the weight on to the outer side of the shoe to such an extent that the shoe quickly becomes distorted. With a level sole or a patch or wedge on the outer border, this over-tilting is avoided and the patient feels more secure or stable. This is no theoretical point. The writer has put it into practice for the past fifteen years and in many cases the patients, who previously had the incorrect alteration, have stated how much better they felt.

Prevention

Finally, two examples have been shown of the importance of dealing with inherent latent defects in early life in order to prevent serious disability later on.

The first deals with one cause of hallux rigidus and the second with what is called spastic or spasmodic flat foot.

A frequent cause of hallux rigidus is exemplified by the case of a lady who has a normal right foot. The left first metatarsal is hypermobile or incompetent. As a result, the foot fell over into pronation. As usual her foot tries to compensate for the poor support of the first metatarsal by powerful flexion of the great toe. This results in spasm of the short flexors of the great toe, which results in the loss of the movement of dorsiflexion at the metatarso-phalangeal joint. When she walks each step causes impingement or jarring between the metatarsal and the phalanx (fig. 10). Impingement causes irritation and finally osteoarthritis, which is hallus rigidus. Hallux rigidus causes pain in the great toe, and, owing to inability to walk properly, much strain in the whole foot and leg, to be cured only by an operation.

Spasmodic flat foot arises in a similar way, except that osteoarthritic changes are very late and the parts affected are the mid-tarsal and subtaloid joints. We find it in adolescents and nearly always they have just started a job which involves prolonged standing and walking. Sometimes there has been

a definite sprain due to an accident. When seen, the cause appears to be an arthritis of the sub-taloid or mid-tarsal joint, with protective muscle spasm. But the cause of the arthritis is regarded as obscure. There is not the slightest doubt in the writer's mind that injury and infection are merely exciting or secondary factors. The basic cause in most cases is pronation of the foot, due to structural defects, which causes or permits the onset of an irritative

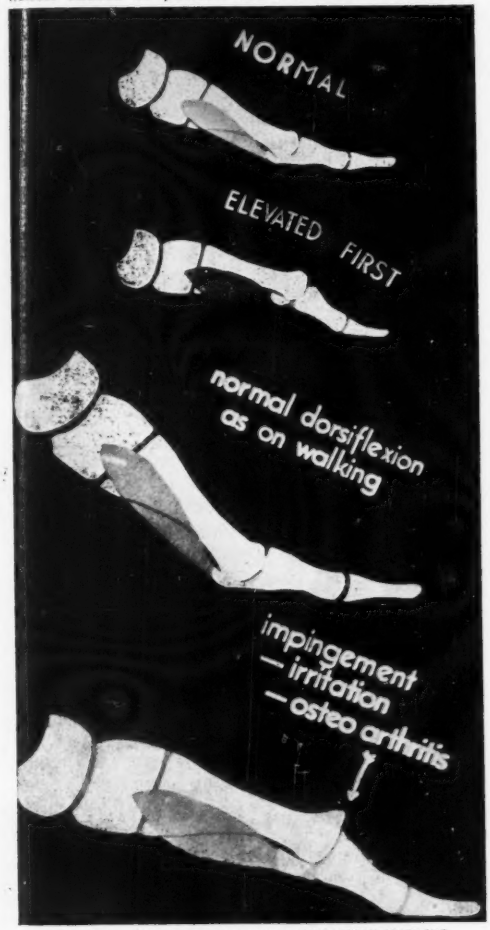


FIG. 10.—The common cause of Hallux Rigidus.

arthritis. The spasm is the usual protective for the joints. Injection of a local anaesthetic into the joints breaks the reflex arc, whilst rest relieves the irritation of the articular surfaces. When the muscles relax we see a typical mobile pronated foot.* If the spasm has been present for some time a local anaesthetic may not be sufficient because adhesions are present. Under a general anaesthetic the adhesions can be ruptured and full mobility obtained. To be absolutely certain that there will be no recurrence it is often necessary to operate to correct the elevated first metatarsal or supinated fore-foot.

* Since the lecture was given the last link in the chain of evidence has presented itself. In 1942 a boy of fifteen was treated conservatively for pronated foot due to elevated first metatarsal. He ceased attending after a period. In July, 1943 he re-attended because of pain, and on examination a typical spasmodic flat foot was found. Until this case one could not present indisputable evidence that the structural defect and pronation preceded the spasm, and were not coincidental or even of subsequent onset.

Preventive Measures in Childhood

In childhood there should be a regular inspection so that at the first sign of abnormality inside or outside the foot the appropriate measures may be put into force. We must supervise footwear and it is possible that we shall have to decide that, at least in the case of city children, all shall wear special shoes. They would probably be of the 'twisted last' type with which the Boot and Shoe Trades Research Council has been experimenting. In brief, the last on which the shoes are made is so shaped that the heel is a little inverted and the fore-foot everted because of increased thickness of the inner border of the heel and of the outer part of the sole.

Stockings must also be examined to make sure that there is plenty of room for the toes, for constricting socks are a very potent cause of foot complaints.

Prevention for Adults

All individuals who are to do work involving a good deal of strain on the foot, such as standing at a machine or driving a tram or who have to walk about all day in an awkward way like waitresses, who carry trays and cannot swing their arms and body—all those who have been in bed for more than a very few days, particularly if they have had toxic illnesses like tonsillitis or 'flu—all who have put on weight must be examined to exclude the conditions here discussed. Unsuitable cases must be directed to more appropriate jobs. Doubtful and unsuitable alike must be given the correct type of footwear, such as the 'twisted-last' shoe. As a substitute the wedging may be added to ordinary good shoes. A massage department of complexity and size depending on the nature of the problem must be set up. A skilled chiropodist should give regular attention to all the employees once a week or once a fortnight. The construction and operation of the processes which are known to lead to foot symptoms must be subject to review for advice as to modification which will eliminate incorrect posture or displacement of the centre of gravity of the body.

Conclusion

The various points here brought out have, it is hoped, shown that the problem of foot fatigue is not so difficult as it seemed. To deal with it successfully necessitates a certain amount of specialized knowledge and a definitely specialized type of mind.

But if the conception of muscle strain or fatigue due to structural defects or reflex causes is always in front of the mind the greatest part of the difficulty has disappeared and we are capable of relieving the complaints of our patients whether civilians, in industry or in the armed forces.

NOTE.—The illustrations are from a cine film available on application to the author.

MEDICAL SERVICE IN INDUSTRY IN THE UNITED STATES

BY

ORLEN J. JOHNSON

(American Medical Association. Council on Industrial Health)

Without question, the health of the American worker is receiving more attention than ever before. While there has been a gradual development in industrial medical service since the inception of workmen's compensation laws earlier in the century, the greatest advancement has taken place since the beginning of the defence programme. Upon the entrance of the United States into the war, there was another definite upward trend in the emphasis placed on the health of the industrial worker. It was recognized that rapid expansion of military forces would cause a shortage of labour and necessitate keeping the remaining working force in a state of highest productivity, which means good health.

Occupational Disease Control

There are in general two types of legislative enactments in the United States which have a bearing on health or working conditions as they affect the worker. One is the Walsh-Healy Act, a federal regulation which requires that industries with contracts for war material over $5000 maintain certain health standards in the working environment. The enforcement of this Act was delegated to the labour departments of the individual states. Ostensibly, the contracts would be revoked if an industry failed to meet these standards. Other legislation which affects working conditions and stimulates medical service is the state and federal occupational disease and compensation laws. These occupational disease laws are in some instances separate enactments from those governing injuries from industrial accidents. They provide that compensation will be paid to the workman afflicted with disease arising out of and in the course of his occupation. They contain no regulations controlling working environment. The laws are of two types:

1. Compensation shall be paid for any bodily injury (disease) resulting from work.

2. Compensation for only those conditions or diseases listed in the law.

Types of Industry

An analysis of the task is necessary before solution. In the production of war materials there are:

1. Government owned and operated ordnance plants under the direction of the Army and Navy. Their health problems are under the direct supervision of the occupational hygiene division of the respective service. For the most part they are staffed by military medical officers, but it has become necessary in some instances to use civilian physicians on a contract basis.

2. Government built and owned, but privately operated plants. For the most part these are large organizations. The operators of these properties are required to maintain definite standards of medical and nursing service by contracted regulation.

These first two types of industry require little or no attention from outside agencies.

3. Privately owned and operated plants which have been converted to the production of war materials. These may be divided into large and small. For many years the large plants have found it desirable to have a medical service and do not present a problem, although it may be stated that recent emphasis on the preventive aspects of industrial health has served in a large part to improve their medical progress also.

The last type of industry and that which presents the greatest problem, are the small plants employing 1000 workers or less. Numerous surveys before the war indicated that 93 per cent. of all industries in the United States employed less than 500 workers and 63 per cent. of the working population was in these smaller plants. Since the great industrial expansion with the war has increased the number of employees in every plant, these figures are no longer accurate. But more recent surveys seem to indicate that over 70 per cent. of all industries still employ less than 500 workers. Because of the rapid expansion and shifting population, no definite figure can be given as to the percentage of workers employed in the last group. But it is safe to say that it is well over 50 per cent. The type of medical service existing in these smaller plants leaves much to be desired, with probably less than 4 per cent. having what is called an adequate medical programme. That is, with nursing and medical personnel in the industry carrying out preventive and case finding activities.

Industrial Health Agencies

As in all social development in the United States, there are definite attempts to bring about the desired

changes voluntarily through good leadership and education. The basis of such an arrangement is that regulations will be met only if enforced, while the wisdom of improved procedures will be followed more rapidly on a broader scale if carried out in a voluntary manner following education.

The agencies interested in industrial health may be divided roughly into governmental and private, each having its own programme for the promotion of its ideas. This obviously has led to considerable duplication of effort, some of it wasted. Nevertheless, the results and increasing interest are evidence of the desirability of this type of activity, though there is still much to be accomplished.

Heading the governmental agencies, which are interested in industrial health, are the U.S. Public Health Service, through its Division of Industrial Hygiene; the U.S. Department of Labour, the War Manpower Commission, the War Production Board, the Maritime Commission and the health departments of the individual states. Among the private agencies working in this field are the Council on Industrial Health of the American Medical Association, the Industrial Hygiene Foundation, the National Association of Manufacturers with its local state organizations, the American Association of Industrial Physicians and Surgeons, the American Public Health Association, the American Industrial Hygiene Association and the U.S. Chamber of Commerce.

Industrial Health Activities

The essence of the programme of each is the prevention of lost time in industry from sickness and accidents, occupational or non-occupational, which has a bearing on the production of war material.

The Division of Industrial Hygiene of the U.S. Public Health Service has been given the responsibility of supervising, with its technical staff, the working environment of the government-owned and privately operated ordnance plants. The services of its staff are available to privately owned industries as well, on request of management. They also carry out research on the toxicology of materia used. Their services are of a consulting nature—they have not sought the power of regulation and enforcement. It can be stated that this authority is not necessary inasmuch as there generally is willingness on the part of the management to carry out their recommendations. They have found that an educational programme is more far-reaching than enforcement. Many health problems have developed with the introduction of new processes and substances. The hazards and methods of control are studied by the Division of Industrial Hygiene as well as by the Army and Navy. The other governmental agencies interested in the health of the worker, for the most part, offer no technical assistance, but rather are promoting medical programmes on a broader scale with the use of the technical services of the local bureau of industrial hygiene.

Thirty-eight states and six cities have Bureaus of Industrial Hygiene in their health departments—with two exceptions where they are in the state labour department. The function of these bureaus is to examine the working environment of privately owned and operated industries at the request of the plant management. These local bureaus, as well as the U.S. Public Health Service, recommend to industrial management improvements in medical service and the working environment. On their advice it is that various programmes of preventive medicine are introduced. Some of these state bureaus have mobile units for chest x-rays as part of the services available. They also provide for free serological examinations and other laboratory facilities.

The U.S. Department of Labour confines most of its attention to accident prevention through nationwide Committees for the Conservation of Manpower in War Industries. They have undertaken an educational programme in almost all areas throughout the country, which consists of a short course in accident prevention and the control of health hazards.

The National Association of Manufacturers has conducted surveys of medical services in plants and sponsored programmes in selected areas in the country to stimulate the interest of manufacturers in providing good medical services. The U.S. Chamber of Commerce is just now beginning to undertake a similar programme.

The Industrial Hygiene Foundation is supported by private industries entirely. It offers a technical service for surveys of working conditions in the plants of its members, and also carries out considerable research in the toxicology of various substances used in manufacturing.

Medical Organization

A challenge to American medicine was laid down by the government, offering physicians the opportunity of solving this problem of improving and extending preventive health services in industry. Feeling that it is the responsibility of the medical profession to maintain the leadership in all matters of health, the profession has undertaken, through the American Medical Association and local medical societies, to attain this end as far as possible.

The aims of these organizations in no way conflict with any other agencies. If anything, they are broader in the scope of their objectives, probably because they have a more intimate grasp of the needs of the problem. The matter has evolved into one of promotion and education of all interested parties, such as industrial management, the worker and the medical profession.

To maintain leadership, the American Medical Association adjusted the programme of its Council on Industrial Health to meet the demands. Consequently, the Council of Industrial Health has stimulated the formation of committees on industrial health in forty-six out of the forty-eight state medical societies, and with their co-operation, is attempting to—

1. Bring about the extension of medical service in more industries.

2. Improve the medical service now being rendered.

3. Stimulate the interest of medical profession and manufacturers alike as to their responsibilities and the value of industrial health.

4. Set up programmes for the procurement and training of physicians to work in both large and small plants where needed.

When one considers that the type and extent of industrial practice, particularly in small plants, throughout the country previously confined itself to the treatment of injuries, it can be seen that this programme entails a large amount of work. The medical profession does not stand alone in the advancement of this activity, as it has been found advisable and profitable to work with all the interested agencies previously mentioned. The amount of progress cannot be accurately measured as to the increased number of improved medical departments, but it is clearly discernible that there has been marked progress in the short time that the pressure has been so great. One of the aims of the Council on Industrial Health is to make medical service in industry not only a war-time programme, but a prominent feature of the practice of medicine and industrial management to meet the changes which must be faced in the post-war era.

'An Outline of Procedure for Physicians in Industry,' published by the Council on Industrial Health in 1942, states that 'the purpose of medicine in industry is to promote the health and physical well-being of industrial employees. These objectives should be accomplished by—

'1. Prevention of disease and injury in industry by establishing proper medical supervision over industrial materials, processes, environments and workers.

'2. Health conservation of workers through physical supervision and education.

'3. Medical and surgical care to restore health and earning capacity as promptly as possible following industrial accident or disease.'

The American Medical Association maintains the position that it is not the responsibility of industry to render medical or surgical care which is not directly attributable to the worker's occupation, although, as stated above, it is within the provinces of industrial medical service to aid in health education and physical supervision of employees in the plant, referring the employee to a physician of his choice for any necessary remedial care. This publication also outlines the duties of a physician in industry as supervisor of plant sanitation and control of occupational disease hazards, preplacement and periodic physical examination of employees, programmes of health education for workmen about hygienic living both in and out of the industrial environment, necessary care for occupational disease and injury and the associated administrative duties.

Many of the large plants with a full-time medical staff do carry out these functions in their entirety. It is the objective of all interested agencies to bring out this type of medical service in all plants regardless of size, utilizing part-time medical and nursing service sufficient to care for the needs as determined by the nature of the processes and character and size of the working force. But, as stated previously, the number of small plants with a well-balanced programme is pitifully low.

Health of Workers

It is recognized that to improve the health of the worker requires reaching the individual and gaining his or her co-operation. There are many factors which are not directly associated with industrial employment such as recreation, housing and nutrition. Definite programmes in this field for industry and the medical profession have been drawn up, but the forces of the workers' own organizations (unions) have not been in general pointed in this direction. Much remains to be accomplished by the workers' groups to improve the health of their members through an educational programme and abetting industrial health as a whole.

Medical Service in Small Plants

The types of stimulating programmes which are in progress throughout the country to improve the situation consist of co-operative plans for the medical profession, manufacturing organizations and governmental agencies. This effort consists of meetings participated in by representatives of these organizations to educate the medical profession as to their responsibility and industrial management as to the value of industrial health. The programmes are designed for the most part for small industries. In conjunction with these meetings a plan is set up whereby the medical service outlined can be obtained. There are three ways in which small industries are meeting their medical needs:

1. By arrangement with an individual physician and nurses to spend the amount of time necessary in the plant for health supervision and other duties. This type of service is most prevalent and of longest standing.

2. A physician and a corps of nurses render the necessary service on a part-time basis to a group of small plants, usually in a rather restricted area. This type of mobile unit has been in existence for seventeen years in one large city, but has not been utilized to any great extent elsewhere.

3. A co-operative arrangement between the local medical society and industries whereby the medical society provides a rotating service by the physicians of the community. The plan is usually developed by joint committees on industrial health from the local medical society and manufacturers' organization. A physician is assigned to spend a predetermined amount of time in each of the plants participating for one month. Remuneration is made directly to the physician by the industry in which he serves on an hourly fee basis. This plan is new and an outgrowth of the increased emphasis on the preventive aspects of industrial health in the last few years.

While it was stated that few small plants have an adequate medical programme by this standard, the

use of preplacement physical examinations is almost universal—the prospective employee being examined in the physician's office. In this arrangement rarely does the physician visit the plant to acquaint himself with the industrial environment.

The Council on Industrial Health has stated that one of the cardinal principles of industrial medical service is that a physician shall spend a certain amount of time in the plant carrying out the duties which are necessary. They no longer believe that a physician on call for the treatment of injuries adequately discharges his responsibilities, nor is he aware of the physical demands on the workers in various jobs if he does not visit the plant. The promulgation of these and other modern concepts form the background for stimulating undergraduate and post-graduate education in industrial health. There is an increasing amount of time being spent on the teaching of this subject in medical schools.

The post-graduate education is sponsored by medical societies, health departments and medical schools. It consists of special meetings on the subject to assist the physicians in private practice. Special courses of three weeks duration are sponsored by the same group to acquaint those physicians going into war industries with the fundamentals of industrial health.

Procurement and Training of Physicians

The selection of physicians to work in industry is left almost entirely to the plant management, although the committees on industrial health of the local medical societies are being called upon more frequently to provide and judge the qualifications of physicians to work in industry. It has been necessary to utilize in many instances those without industrial experience. Hence the previously mentioned educational courses are becoming increasingly well attended by physicians who desire to equip themselves properly.

Nurses in Industry

The use and functions of nurses in industry is becoming increasingly widespread. By the same token there is a shortage of nursing personnel qualified to fill the positions. The nurse is no longer regarded as merely a first-aid attendant to care for minor injuries, but is becoming educated as rapidly as possible as to her responsibilities in the preventive aspects of industrial health. In conjunction with the plans for providing service to small plants, non-official nursing agencies such as Visiting Nurses Associations are now providing nurses for industry on an hourly basis. During their visits they carry out health education and sanitary inspections. The most frequent use of these organizations, however, is for calls at the employee's home during illness. These visits are not necessarily confined to occupational conditions.

Nutrition

Nutrition is being emphasized quite universally. It is directed toward improving the diets of the workmen at home as well as at work. Many of the large plants have a cafeteria where the workman may secure his noon meal at cost. Mobile canteens are prevalent for between-meal nourishment. The emphasis on nutrition is directed toward a balanced diet.

Women in Industry

Like all nations at war the United States is utilizing the service of women in the production of war material. Many medical problems have arisen coincident to this entry of inexperienced women workers into industry. All agencies, governmental and private, are giving them serious consideration. Many recommendations have been issued relative to hours of work, training, clothing, nutrition, lifting, medical supervision and other problems created.

In some states some of the laws regulating the work of women have been set aside temporarily in order that they may work longer hours and at night.

Ancillary Services

There is great variation in the furnishing of ancillary services by industry such as dentists and visiting nurses. Those dentists who work in the larger plants as a rule do extractions and give prophylactic treatment only. In the main this type of service is not prevalent.

A few mines and an occasional plant provide ultra-violet rooms. The experience in the matter is too limited to draw any conclusions.

Distribution of Physicians

In order to handle the medical needs of the military forces, the Procurement and Assignment Service for Physicians was set up by the federal government. While this is an official agency, the securing of medical personnel is, to date, on a voluntary basis entirely. We all recognize that next to the medical needs of the armed forces, the health of the war worker is second only. With this in mind, the Procurement and Assignment Service has designated that certain industrial physicians are not available for military duty. Naturally these standards have varied as the size of the Army and Navy increased. In order to provide physicians to work in war industries, the Procurement and Assignment Service asked the Council on Industrial Health of the American Medical Association to set up a training programme for over-age physicians and those rejected for military duty because of physical disability.

To date it appears that the demands of industry are being met quite satisfactorily, but without doubt, when industrial management becomes more aware of the necessity for health programmes, some difficulties will be experienced in supplying adequately trained physicians.

It is the aim of all private enterprises to supply the medical services necessary for the military force, industry and the civilian population—on a voluntary basis. And under this programme it can be said that demands are being met without regimentation by governmental legislation.

THE BRITISH JOURNAL OF INDUSTRIAL MEDICINE

Introductory

Only a very strong case would justify the launching in time of war of a new quarterly journal. Such a case, we believe, has been made out for the *British Journal of Industrial Medicine*, of which this is the first number. Indeed, had it not been established to the satisfaction of those responsible for its actual publication and for allotting the required paper, this journal could obviously not now have appeared, although it has long been envisaged by many medical men and women engaged in industrial medicine. Before the war, Medicine had of course touched industry at various points. The particular hazards involved in certain types of process and manufacture had called for special research and the adoption of precautionary measures, in many cases enforced by legislation; and these had formed the study and administrative concern of a group of doctors, both inside and outside various Government Departments. The examination of entrants to industry, particularly juveniles, had been a main task of certifying factory surgeons. The Post Office, as the largest single industrial concern in the country, had provided free medical attention, since the middle of the last century, for all its employees below a certain salary, and had been keeping accurate sick records of its whole staff for very many years past. More recently, certain large industrial concerns had begun to employ whole-time medical advisers to deal with such questions as working conditions, toxic hazards, the treatment of accidents, rehabilitation and general sick absence problems.

It was this movement that brought into being in 1935 the Association of Industrial Medical Officers, whereby doctors thus employed in a whole-time capacity in various branches of industry could meet for a pooling of experiences, mutual help and advice and for the furtherance of research. Sir Wilson Jameson, then dean of the London School of Hygiene and Tropical Medicine, was consulted and gave the young movement much valuable practical assistance; and within two years the Association had come to include eight honorary and forty-six ordinary members. In 1937 it was invited to give evidence before the Interdepartmental Committee on rehabilitation of persons injured by accident; in 1938 it was officially invited by the Home Office to discuss the problem of Air-Raid precautions in factories; and in 1939 it was asked to give evidence before the Royal Commission then considering Workmen's Compensation.

Since the outbreak of war there has, of course, been an enormous development of industrial problems with a medical aspect. Great new industries have come into being. Scores of thousands of men and women and girls and boys have been introduced—many of them for the first time—into factory life in necessarily strenuous and unaccustomed conditions. New toxic and other hazards have arisen in the wake of invention and the extension of war work to factories hitherto otherwise employed ; and a very large number of new factories have come into production in all parts of the country.

All this has brought into contact with industrial life an increasing number both of whole-time and part-time doctors. The Association of Industrial Medical Officers now in itself has more than three hundred members; and in addition, large numbers of nurses and welfare officers are—many of them for the first time—being confronted with daily problems in which Medicine is directly or indirectly concerned. It was therefore felt that the time had come when such a journal as this might be of great value to a considerable and influential body of workers not only in factories but in mines, shipping, docks, the transport services and in clerical and commercial organization; and thanks to the very great help of the British Medical Association, under whose aegis it is appearing, the initial obstacles were met and overcome.

Briefly, the *British Journal of Industrial Medicine* is intended to include, within one pair of covers, not only original articles and notes with a definite industrial bearing but abstracts from those many other journals—published both here and abroad—which may contain material of value to any doctor engaged in advising upon, or actually treating, industrial staffs. These doctors are usually more than fully occupied. Many of them are in relatively remote places, or at any rate not in a position to attend libraries or lectures, or to read for themselves a multiplicity of medical journals. It is also believed that this journal may be of some interest—and it is hoped value—to many employers of industry, whether State or private. The standard that it has set for itself is to be objective and scientific, in the broadest sense of the latter term, and it has no political bias.

It will be realized that it is, at the moment, being produced in extremely difficult conditions. It cannot expect to attain perfection, or anything near this, at a bound; and the editors will be only too glad to receive criticism and constructive ideas. Series of authoritative articles are being arranged for which will deal with industrial environment, toxicology and the particular hazards met with in different industries; and original contributions will always have the warmest welcome and most careful consideration. Although our title is the *British Journal of Industrial Medicine*, it is hoped in time to associate with it representatives of industrial medicine in the Dominions and United States of America.

ABSTRACTS

Measurements of Concentrations of Air-Borne Dusts. BEDFORD, T. and WARNER, C. G. *Journ. Indust. Hyg.*, 1942. December. Vol. 24, No. 10, pp. 315–21, 3 figs. (12 refs.).

Estimations of the concentrations of fibrosis-producing dusts met with in industry can be expressed in terms of the mass concentration of the dust or of the number of particles in unit volume of the dust cloud, but the former measure of dustiness is probably not the best index of danger to health, in that large dust particles are of little pathological significance though they have a great effect on the mass concentration. It is stated by Bloomfield and Dalla Valle that high correlations exist between counts and weights, but the coefficients adduced by them are not high enough to enable either of the indices of dustiness to be estimated from the other with great accuracy. The present investigation relates to anthracite mines in South Wales, and dust concentrations were determined, both as mass concentrations and as particle counts. Most of the observations were made by the thermal precipitator method, but at two collieries naphthalene filter samples were taken simultaneously, and a comparison of the gravimetric results obtained by this method with estimations from the thermal precipitator records (based on the assumption that the particles of dust were spherical and had the average specific gravity of the dust) showed that the gravimetric values were about one-and-a-half times the corresponding thermal precipitator values. Probably the discrepancy was due to the inclusion or exclusion of a few very large particles in the evaluation of the thermal precipitator values. The effect of a few large particles was well shown at one colliery where some particles were as large as 50 microns. Calculation of the correlation coefficient between the count of all particles and the corresponding mass of all particles gave values of 0·20 and 0·47 in two series, but when the count of all particles was compared with the mass of all particles up to 5 microns the coefficients were raised to 0·95 and 0·76. The majority of the particles counted were below 1 micron in size, but in spite of their number these particles had only a small effect on the total mass of the dust. Hence it appeared that a higher correlation between particle count and mass concentration would be obtained by omitting from the count all particles smaller than 1 micron. This expectation was justified, coefficients of 0·99 and 0·97 being obtained when counts of particles larger than 1 micron were compared with the mass of particles up to 5 microns. It appears to follow that if the mass concentration of the restricted range of particle size is regarded as the pathologically significant value, it is not worth while to determine mass concentrations gravimetrically. More accurate information can be obtained by the readier method of counting particles larger than 1 micron. H. M. V.

An Investigation into the Effects of Continued Exposure to the Vapour of Volatile Solvents. KILLICK, ESTHER M. and SCHILLING, R. S. F. *Journ. Indust. Hyg.*, 1942. December. Vol. 24, No. 10, pp. 307–14 (29 refs.).

In the paint industry a large number of volatile substances are used as solvents and diluents, and as they are frequently employed in the form of complex mixtures it is difficult to assess the degree of exposure of the workers to each individual substance. Hence it seemed desirable to ascertain the clinical state of men using such mixtures, and to examine their blood. The solvents mainly used were toluene, xylene, butyl acetate, acetone and petroleum solvent. The 30 workers at a paint factory were examined, and as a control, 7 men employed at a neighbouring metal foundry. The average differential blood count of these controls showed 60 per cent. of neutrophils and 34 per cent. of lymphocytes, whilst the erythrocytes numbered 5·33 million per c.mm. and the haemoglobin 15·0 gm. per 100 c.c. In comparison, the various groups of paint workers showed very little deviation in respect of erythrocytes and haemoglobin, but more definite changes in the leucocytes. In place of the 8600 leucocytes per c.mm. shown by the foundrymen, there were from 7200 to 7780 in four of the six groups, and the neutrophils averaged only 38 to 54 per cent. of the total, whilst there was a corresponding excess of lymphocytes.

As regards clinical symptoms, 15 of the 30 men complained of headache, 20 of slight narcosis, and 10 of indigestion. One man was definitely reported as suffering from solvent poisoning, and did not return to the paint factory. He had been employed for a year on solvent mixing, and when tested at the end of this time he had 5870 leucocytes per c.mm., of which 40 per cent. were neutrophils and 55 per cent. lymphocytes. He got employment at the foundry above mentioned, and after 4 months his total leucocytes had risen to 6875, the neutrophils forming 62 per cent., with a corresponding reduction of lymphocytes. This result tends to confirm the hypothesis that the blood changes previously described were due to the volatile solvents employed.

H. M. V.

Acute Experimental Aniline Intoxication. CLARK, BYRON B., VAN LOON, EDWARD J., and MORRISSEY, ROBERT W. *Journ. Indust. Hgy.*, 1943. January. Vol. 25, No. 1, pp. 1–12, 3 figs. (48 refs.).

Acute aniline intoxication in man has the following characteristic symptoms: cyanosis, headache, dizziness, muscular weakness, and in more severe poisoning, ataxia, impairment of consciousness, and coma. The pulse is usually rapid and somewhat weak; the blood pressure may be increased at first, and later decreased. With severe intoxication there is marked dyspnoea on exertion. Methaemoglobinemia is produced, and the effects appear to run parallel to the intensity of the methaemoglobinemia in man and in the dog. In addition, aniline may have a direct action on the heart, blood vessels and nervous system, and some investigators concluded that in acute aniline poisoning death is usually cardiac, but this view has not been confirmed by clinical observations.

The present investigation was made on dogs. In 30 experiments on unanaesthetized animals aniline was administered by stomach tube as a 2 per cent. solution in saline, in doses ranging from 10 to 400 mgm. per kgm. body weight. The methaemoglobin reached a maximum in 2 to 7 hours, and with 100 mgm. of aniline 70 per cent. of the haemoglobin was converted into methaemoglobin. Usually after 24 hours very little methaemoglobin remained as it had been reconverted to haemoglobin, but with doses of 200 mgm. or more a maximum concentration of 70 to 75 per cent. of methaemoglobin was maintained until the death of the animal in 10 to 20 hours. A 50-mgm. dose of aniline caused a 50 per cent. formation of methaemoglobin, but the blood pressure was not significantly altered, though usually the heart rate increased. In a few instances there was some degree of lethargy, though there was no evidence of leg weakness

or inco-ordination. With a dose of 75 mgm. of aniline lethargy was more marked, and ataxia occasionally showed itself.

In the experiments on anaesthetized animals a dose of 30 to 35 mgm. of pentobarbital sodium was introduced intraperitoneally. When saline containing 0·5 to 2·0 per cent. of aniline was injected intravenously and continuously till death, with a total dose of about 500 mgm., the respiratory rate gradually rose to four times its initial value. Heart rate and blood pressure increased for the first hour or so, and then rapidly fell. In other experiments a single dose was injected. Electrocardiograms were taken and records are given in the paper, with a discussion of their significance. The aniline evidently has a direct action on the central nervous and cardio-circulatory systems, either stimulation or depression being produced, but relatively high concentrations of aniline in the blood are necessary to demonstrate these actions. Methaemoglobin, like carbon monoxide-haemoglobin, cannot transport oxygen to the tissues, so methaemoglobinemia results in a decrease in the arterial oxygen content corresponding to the proportion of methaemoglobin present. The anoxia is responsible for most of the effects produced by oral ingestion of aniline, and in order to demonstrate the direct action it is necessary to ingest aniline intravenously. Methaemoglobin soon begins to accumulate, and the effects are then due partly to its action. H. M. V.

Experimental Studies on Lead Absorption and Excretion and their Relation to Diagnosis and Treatment of Lead Poisoning. KEHOE, ROBERT A., CHOLAK, JACOB, HUBBARD, DONALD M., BAMBACH, KARL, and MCNARY, ROBERT R. *Journ. Indust. Hyg.*, 1943. February. Vol. 25, No. 2, pp. 71–9, 6 figs.

A healthy experimental subject (E. B.) was given 2 mgm. of soluble lead per day for a continuous period of 23 (lunar) months, and his blood and excreta were analysed regularly. The urinary lead output increased gradually, though rather irregularly, from 0·037 to 0·136 mgm. per day, and the blood lead increased from 0·029 to 0·072 mgm. per 100 grams. When the administration of the lead was discontinued, the decrease of lead in the urine and blood was very gradual, and it did not quite return to normal in the period of 16 months for which it was observed. The subject of experiment had no symptoms of illness, no lead line, and no change in the number of stippled erythrocytes, though the lead absorption was at a potentially dangerous level. The faecal lead reached a point very near its maximum within a few days after the start of the administration, and after its cessation it soon fell to the normal minimum (due to small quantities of lead in the food and drink ingested); i.e. there was no appreciable elimination of lead from the tissues by way of the alimentary tract.

Another subject (M. R.) was given 1 mgm. of lead per day for 40 months, and he accumulated lead in his body at a less than proportional rate as compared with the first subject. This suggests that there is a point of lead intake at which no measurable accumulation will take place in the body. The point was calculated to correspond to an oral intake of soluble lead not exceeding six-tenths of a milligram per day. Another calculation showed that subject E. B. retained 110 mgm. of lead in his tissues as the result of the 23-month lead administration, and that 16 months after it was stopped he still retained 70 mgm. If the excretion continued at the same rate he would have taken 44 months to reach normality. The addition of large quantities of milk or ascorbic acid to the dietary of subject M. R., and variations in his calcium and phosphorus intake, had no appreciable influence on the absorption and gross retention of the lead. H. M. V.

Measurement of Industrial Lead Exposure by Analyses of Blood and Excreta of Workmen. CHOLAK, JACOB and BAMBACH, KARL. *Journ. Indust. Hyg.*, 1943. February. Vol. 25, No. 2, pp. 47–54, 3 figs. (16 refs.).

The authors used dithizone, spectrographic and polarographic methods of analysis, and found that they had approximately equal sensitivity and precision. The average results obtained with numerous analyses on a number of normal persons showed the lead concentration to be 0·030 mgm. per 100 grams. of blood, 0·027 mgm. per litre of urine, and 0·27 mgm. per 24-hour faecal sample. In comparison, garage mechanics had 0·039 mgm. in their blood, 0·050 mgm. in urine and 0·486 mgm. in faeces. Workers on lead tetraethyl had 0·045 mgm. in blood, 0·093 mgm. in urine and 0·458 mgm. in faeces, but the highest values were observed in workers employed in the manufacture of storage batteries (0·182 mgm. in urine and 2·530 mgm. in faeces), and in the manufacture of white lead, the men with severe exposure having 0·336 mgm. in urine and 7·60 mgm. in faeces. The urinary and blood analyses provided a better criterion of exposure than the faecal, especially under conditions of exposure to volatile lead compounds and fume. When the predominant lead exposure occurred through the inhalation of dusts, the greater portion of the lead found its way into the faeces. The maximum effects of occupational lead exposure may not be reached for a long time, e.g. in the detailed instance cited the urinary lead took three years to reach it.

H. M. V.

Measurement of Industrial Lead Exposure by Determination of Stippling of the Erythrocytes. SANDERS, LESTER W. *Journ. Indust. Hyg.*, 1943. February. Vol. 25, No. 2, pp. 38–46, 11 figs. (11 refs.).

Investigations were made on 2231 petroleum refinery employees, on 82 medical students and on 60 primitive Mexicans, all of whom were unexposed to any known lead hazard, and on 20 workmen employed at a brass foundry where there was a definite lead exposure. An examination of blood smears showed that stippled erythrocytes occurred in healthy unexposed individuals, and also that heavy exposure could exist without their occurrence either in the individual or the group. It follows that positive results are diagnostic in the individual only in extremely high numbers such as over 5000 stippled cells per million, but a mean of over 1000 cells per million in a group suggests increased lead absorption if other known causes are ruled out. Individual or group findings in excess of 9000 stippled cells per million defines lead intoxication in the absence of other recognized causes such as pernicious anaemia.

H. M. V.

Health of Lead-exposed Storage Battery Workers. DREESSEN, W. C. *Journ. Indust. Hyg.*, 1943. February. Vol. 25, No. 2, pp. 60–70, 4 figs. (18 refs.).

Environmental studies were made in 13 representative storage battery plants, and medical studies in 6 plants. The manufacturing operations involved exposure to the dust of red lead and litharge, and to lead fumes. In all, 288 air samples were collected, having an average of volume of 6 cubic metres (215 cubic feet). They were collected in 100 c.c. of diluted nitric acid, and were analysed by the Fairhall volumetric chromate method. About half the personnel at the 13 plants were working in an environment in which the air contained more than 1·5 mgm. of lead per 10 cubic metres of air. The lead exposure of the smelterers ranged from 0·1 to 19·2 mgm.; pasters, 1·2 to 88 mgm.; oxide mixers, 0·8 to 36·9 mgm.; group assemblers, 1·0 to 28·5 mgm., etc. In general, the lowest lead values were attributable to control measures such as local exhaust, enclosure, wet methods and improved general ventilation.

A medical study was made of 766 men in all. None of them showed the classical symptoms of lead intoxication; but 168 showed evidence of abnormal lead absorption and subclinical plumbism, while 9 were regarded as having incipient plumbism, for almost all had blue line of gums, tremor, pallor and high lead values in the blood and urine. In the men as a whole symptoms were relatively infrequent. Those significant of lead exposure related to the gastroenteric tract. Pallor and tremor were fairly common, and metallic gum line was observed

in 88 of the workers. The incidence of the 'early plumbism' increased with increasing lead concentration, only 4 per cent. of those exposed to 0·74 mgm. lead per 10 cubic metres being affected, rising to a maximum of 54 per cent. of those exposed to over 3·0 mgm. Albuminuria was found in 115 (15 per cent.) of the men, and was twice as frequent in the lead-affected group as in the non-affected group. The lead content of the blood varied roughly with the atmospheric lead concentration, averaging 0·026 mgm. per 100 grams of blood when the air contained less than 0·75 mgm. of lead per 10 cubic metres, and increasing to an average of 0·050 mgm. when it was over 3 mgm. per 10 cubic metres. The urinary lead varied in similar fashion with the lead in the air. The prevalence of arteriosclerotic-hypertensive heart diseases did not appear to increase with increasing lead concentration, the average systolic and diastolic blood pressures increasing with age to approximately the same degree in lead storage battery workers as in other groups of industrial workers. H. M. V.

Non-fatal Effects of Exhaust Fume Poisoning. EURICH, F. W., M.D. *Brit. Med. J.*, 1943. March 13, pp. 326.

In this paper, Dr. Eurich describes four non-fatal cases of poisoning by the exhaust fumes of cars. He suggests that such cases are more likely to occur in the future, as cars must of a necessity have a much longer life than in former days.

The symptoms of such poisoning are weakness of the legs, headache and dizziness. They are rapid in onset, generally within twenty-four hours. In some cases there is disorder of the pupil reaction and weakness or absence of the ankle jerks.

In the cases described, carbon monoxide could not be demonstrated either clinically or spectroscopically in the blood and the diagnosis depended upon the rapid development of symptoms following exposure to fumes caused by defective ventilation in a car.

Dr. Eurich states that the prognosis is apparently good, although convalescence may be prolonged.

J. W. P.

Processing Technics in Physical Examination. WISHARD, FRED B., M.D. *Journal American Med. Assoc.* Vol. 121, No. 11, pp. 108–13.

Dr. Wishard describes the layout of the medical department of an industrial organization in the U.S.A. He stresses the increased work which has occurred during the last four or five years. In many organizations the doctor has to pass all transfers or changes of jobs and works processes with industrial hazards, as well as the day to day medical and surgical work.

In view of this, Dr. Wishard stresses the importance of a well-organized department and procedure of work. In his opinion, it is desirable to provide separate waiting rooms for the two classes of 'patient,' namely, those who are waiting for pre-employment physical examination and those who have been off sick and are reporting back to duty making up the first cases, while the other class is made up of those reporting for treatment, examination and consultation in 'works' time.'

As an x-ray film is taken of all candidates, the waiting-rooms should be arranged round a central radiographic unit.

By careful subdivision and delegation of the individual steps of a physical examination, Dr. Wishard states that he has found it possible to handle 12 to 15 candidates an hour. J. W. P.

Nature, 1943. Vol. 151, pp. 473.

In a letter to the editor, G. N. Jenkins has shown the rate of loss of ascorbic acid in cooked whole and mashed potatoes, after being kept hot for varying lengths of time. He found that the ascorbic acid content of a sample of whole boiled potatoes was 5·4 mgm. per 100 grams, and when mashed, 5·0 mgm. per 100 grams immediately after cooking. If kept at room temperature, at the end of 15 minutes, the ascorbic acid content of whole boiled potatoes was 4·3 mgm. per 100 grams, but if kept in a double saucepan at 80·85° C., at the end of the same period the content was 0·9 mgm. per 100 grams. If the potatoes had been mashed, it was found that at the end of 30 minutes the content was only 0·5 mgm. per 100 grams.

The author points out that there is very little immediate loss of ascorbic acid in mashing small quantities of potatoes, but that the loss is greatly accelerated if the potatoes are subsequently kept hot. Experiments carried out in a canteen confirmed the laboratory findings.

The author stresses the fact that when potatoes have to be kept hot in bulk they should not be mashed. In addition, there is very little difference in the ascorbic acid content of vegetables kept hot in bulk and in individual helpings. J. W. P.

Memorandum on the Prevention of Industrial Dermatitis with Special Reference to the Use of Barrier Substances. FACTORY DEPARTMENT, MINISTRY OF LABOUR AND NATIONAL SERVICE. December, 1942. Form 330, pp. 4. H.M. Stationery Office, London. 1*d.*

Industrial dermatitis accounts for the majority of cases of industrial disease occurring in factories. It can be largely prevented by adopting the following measures:

(a) Selection of personnel where there is a dermatitis hazard.

(b) Protection by the use of gloves, aprons, boots, splashguards, etc.

(c) Direct protection of the skin by the use of barrier substances. Without making reference to particular barrier substances, the general properties required of them are given.

(d) Inspection of the skin surfaces by a nurse or first-aid attendant.

(e) Cleanliness, which can be encouraged by the use of well appointed washing facilities in the charge of a responsible person.

In shops where dermatitis is likely to occur there should be at least one basin for every ten persons, and one for every five persons where poisonous materials are handled. R. S. F. S.

Memorandum on the Prevention of Industrial Dermatitis —Dermatitis from Glues used in Aircraft Construction. FACTORY DEPARTMENT, MINISTRY OF LABOUR AND NATIONAL SERVICE. February, 1943. Form 331, pp. 4. H.M. Stationery Office, London. 1*d.*

Synthetic glues used in the aircraft industry are of two main types, resin glues and casein glues. Both give rise to dermatitis, but the former are more likely to affect the skin because of their common ingredient formaldehyde. Special measures for protection against the occurrence of dermatitis depend on two principles:

1. All glues must be removed from the skin as soon as possible.

2. All traces of chemicals in contact with the skin must be removed or rendered inert before leaving work.

For these purposes the following measures are recommended:

(i) Damp swabs of loosely woven stockinette material or of the knitted dish-cloth variety should be available for all workers using glue.

(ii) Barrier preparations should be applied before work for protecting the skin.

For resin glues it is advised that such preparations containing lanoline should be avoided as it has been suggested that lanoline has an emulsifying action on formaldehyde.

For casein glues barrier preparations designed to give protection against water and aqueous solution of chemicals should be chosen.

(iii) Special soaps for both types of glues are recommended, as it has been found that washing by ordinary methods is ineffective in removing all traces of formaldehyde or alkali from the skin. Washing accommodation should be near the glueing operations, and the supervision of washing, the provision of hot water and

clean towels are necessary if dermatitis is to be controlled.

4. The first-aid treatment of injuries is of particular importance where synthetic glues are handled. Wounds should be suitably covered with an impermeable dressing to prevent contact with glue, and dressings should be renewed as necessary.

A cautionary notice (Form 336) has been prepared for display in factories where synthetic glues are used.

R. S. F. S.

Conference on Industrial Health: Report of Proceedings. MINISTRY OF LABOUR AND NATIONAL SERVICE. April, 1943. Pp. 107. H.M. Stationery Office, London. 1*s.* 6*d.*

This paper gives a verbatim report of the conference on industrial health organized by the Ministry of Labour. Amongst those who spoke were Ministers, Parliamentary Secretaries and shop stewards; employers and trade union representatives; factory inspectors, medical officers, nurses and personnel officers.

Mr. Bevin summarized under the following headings what he hoped the conference could do.

1. Emphasize the vital importance of maintaining and improving the health and environment of workers in the factory and in the office.

2. Crystallize the interest in this subject that has been developed in recent years, more particularly during this war.

3. Secure advice and suggestions for the action which should be taken in the future, both during and after the war, by the Government and by industry.

The conference lasted three days and more than twenty persons spoke in the discussions which followed the twelve papers read on the following subjects: The work of the Factory Department, industry's contribution to positive health, the place of industrial health services within a comprehensive medical service, medical research and industrial health; health in industry from the point of view of the employer, the trades unions and the works medical officer; and medical training in industrial health.

R. S. F. S.

Di-Ethyl Mercury Poisoning. HILL, W. H. *Canadian Journ. Public Health*, 1943. Vol. 34, p. 158.

Hill reports without clinical details, the death of two girls who were stenographers in a warehouse which stored di-ethyl mercury. This was to be used for treating grain for the eradication of smut. One began work on May 7 and died on September 24, the other began on April 1 and died on October 17, 1940. At a distance of 3 feet from a pile of 20,000 lb. of di-ethyl mercury, the atmosphere 3½ feet from the floor contained 2·7 mgm. of mercury per cubic foot of air. The desks of the two girls were about 15 feet from the stock pile.

K. P.

Mass Radiography. Paper read at meeting of Metropolitan Group of the Society of Medical Officers of Health. HEAF, FREDERICK, M.D., M.R.C.P., Principal Assistant Medical Officer, L.C.C. Public Health Department. Reprinted, *Public Health*, July, 1943. Vol. LVI., No. 10.

The author, referring to the use of mass radiography for industrial workers, calls attention to the large number of factories employing small numbers and says that it will not be easy to arrange for the x-ray of the personnel from such places without inconvenience to the management. He quotes from past experience the difficulties that may be encountered on account of the attitude of workers to T.B., the implication being that many fear it so much they would almost rather not know if they did have it. The propaganda for mass x-ray must be handled delicately; there must be no suggestion of compulsion by employers.

The author is against selection of certain occupations for investigation, in case the impression is given that workers in that trade were being subjected to a sifting process not applied to their friends in other jobs.

T. O. G.

Industry's Contribution to 'Positive' Health. Address to Conference on Industrial Health, Caxton Hall, April 9, 1943. JAMESON, Sir WILSON, Chief Medical Officer to the Ministry of Health. Reprinted, *Medical Officer*, May 1, 1943. Vol. LXIX, No. 18. 1 page.

Attention is called to the emphasis being laid on 'positive' health, as against the former conception of health as 'freedom from ill-health.' It has probably been logical that prevention of disease has occupied public health authorities in the past more than efforts to build good health. Industry, particularly through the factory inspectorate, has done much to reduce sickness on account of bad conditions of environment, but it is obvious that industry has a big contribution to make in planning better health generally. There must be decent working conditions, including reasonable hours of work and avoidance of unnecessary anxiety. Expert knowledge must be utilized to overcome the problems of heating, lighting, ventilation and other matters associated with factory hygiene. The author hopes that industry will continue war-time efforts aimed at raising the level of nutrition among workers. Works canteens should remain.

The education of doctors and those associated with the health services must include more knowledge of homes and working conditions of the people. We want this great medical service we are trying to plan to provide continuity of care both in the home and at work.

T. O. G.

Post-Graduate Education of Physicians for Industrial Health Services. (Presented before the Industrial Hygiene Section of the American Public Health Association at the Seventy-first Annual Meeting in St. Louis, Mo., October 28, 1942.) PETERSON, CARL M., M.D., F.A.P.H.A. *American Journal of Public Health*, May, 1943. Vol. 33, No. 5, pp. 3½.

The Directing Board of the Procurement and Assignment Service for Physicians has approved two recommendations of its Advisory Committee on Industrial Health and Medicine. The first defines the essential industrial physician and attempts to stabilize the existing supply. The second recommends 'the creation by the Council on Industrial Health of the American Medical Association of training centres for industrial medical volunteers, using the combined resources of medical schools, bureaux of industrial hygiene and industrial medical departments.' The article goes on to discuss the time required for these training courses and the subject-matter they should cover. The urgency of the whole problem, of course, as in this country, being closely related to the needs of the war effort.

T. O. G.

Action on Finely Divided Magnesium upon the Lungs. (Presented before the Industrial Hygiene Section of the American Public Health Association at the Seventy-first Annual Meeting in St. Louis, Mo., October 29, 1942.) GARDNER, LEROY U., M.D., F.A.P.H.A., and DELAHANT, ANTHONY B. The Saranac Laboratory for the Study of Tuberculosis, Saranac Lake, N.Y.

Recent papers have focussed attention upon the hazards from metallic magnesium. It has been demonstrated that small particles of this metal, imbedded in living tissues, dissolve, with the evolution of hydrogen and the production of an irritating alkaline hydroxide. The tissue response consists of a transitory acute inflammation, which is unique because of the presence of large vacuoles, produced by the presence of the gas. The present writers were interested to discover the particular dangers of inhalation of metal particles into the lungs, although it is realized that, owing to the danger of explosion, the concentration of powdered magnesium in any working atmosphere is likely to be very slight. It was argued that very small particles when inhaled would release their hydrogen in the nasal and bronchial passages without damage and that, even in the lung, released hydrogen would not be in a position to cause

pressure symptoms. Cats and guinea-pigs were used in the experiments, the metal particles being introduced by needles into the larynx and bronchi in the case of guinea-pigs, and through a small bronchoscope in the case of cats.

The conclusion reached at the end of the experiments was that finely divided metallic magnesium does not have the same effect upon the lungs as it exerts on more dense subcutaneous tissue. The absence of 'gaseous tumour' formation is explained by the free communication of the pulmonary air spaces with the external air.

T. O. G.

Unexpected Occupational Disease Exposures during Wartime. (Presented before the Industrial Hygiene Section of the American Public Health Association at the Seventy-first Annual Meeting in St. Louis, Mo., October 27, 1942.) PRENDERGAST, JOHN J., M.D. *American Journal of Public Health*, April, 1943. Vol. 33, No. 4, pp. 5.

It is pointed out that a number of toxic substances are now being used on operations, when before the war safe substitutes were available. The medical director of the Chrysler Corporation gives instances of this happening, stressing the need for the medical staff to be aware of the possibility. He found benzene being used in an operation involving the polishing of reflectors, the production people being quite unaware that benzene was a toxic substance. A survey of a gun plant revealed that carbon tetrachloride in a fairly large quantity was being used in a certain critical tapping and machining operation. Further research enabled them to substitute trichlorethylene, in a much smaller quantity, too.

Lead tetra-ethyl is being widely used in all sorts of motor fuel to increase the octane rating. A particular danger he mentions is where this type of fuel may be used for washing purposes, when previously there was no lead content. An associated problem is the lead content in the atmosphere that may arise in multi-storey buildings where jitney trucks and other motors may be running on the elevators.

Many new substances are being introduced which may cause dermatitis—e.g. solvents, cements, and glues.

A new form of exposure to noise comes from aeroplane motor testing. In the past, these had been kept to a 90-decibel level or lower. With engines of 1500 to 2000 h.p. in the test rooms, noise levels of from 120 to 140 decibels have resulted, in spite of efforts at sound-deadening rooms. All personnel exposed to high levels of sound are now given special physical examinations. In addition to audiometer tests, complete clinical laboratory tests, basal metabolism and electro-cardiography are included.

T. O. G.

Nutrition in War Industry. (Presented before the Sections of Industrial Hygiene and Public Health Nursing at the Thirty-first Annual Meeting of the Canadian Public Health Association, held in Toronto, June 1–3, 1942.) IGNATIEFF, F.* *Canadian Public Health Journal*, December, 1942. Vol. 33, No. 12, 4 pp.

This whole problem can be met by making meals 'attractive, economical, and nutritious.' This particular plant measures its success by the number of workers who continue to carry in their own lunches. The dietician is advised to follow 'the serving of the meal to check the appearance and taste of the food as it passes to the customers.'

Stress is laid upon building up good will with the customers so that they become educable in new dishes. Constant education of the catering staff is also necessary, all must become 'attractive food' conscious. They must also have good wages.

The statement is made that 'the percentage of waste determines the cost of the meal more than the original cost of the materials.'

'Education to develop the attitude of proper healthy eating is achieved through the personnel department and the medical department.'

T. O. G.

* Manager of Cafeteria, Scarbor Plant, The General Engineering Company (Canada), Limited, Toronto.

Byssinosis—Report of Two Cases and Review of Literature. BOLEN, H. LEONARD. *J. Indust. Hyg.*, 1943. Vol. 25, No. 6, pp. 215–224, 4 figs. (37 refs.).

Byssinosis is the form of respiratory disease affecting certain operatives in cotton mills who work in departments in which much dust is given off. The victims develop a dry, irritating cough, with dyspnoea. They become easily fatigued, and in course of time there is a marked decrease in vital capacity. Much tenacious sputum may be expectorated, and the cough becomes distressing. The clinical picture is one of severe chronic bronchitis and emphysema. A Departmental Committee on Dust in Card-rooms, which reported in 1932, found that after the age of 30 the strippers and grinders had a death rate from respiratory diseases which was two to three times as high as that of other cotton industry operatives. The inhaled cotton dust appears to have an allergic action, all the disease operatives examined by Prausnitz (1936) having a supersensitivity to cotton-seed protein, though healthy operatives in cotton mills and other occupations seldom showed it.

The author describes two cases of byssinosis examined by him. One patient, aged 38, was first seen after he had been employed in the card-room for ten years. He had persistent cough and dyspnoea, and a roentgenogram showed chronic bronchitis with an area of density in the right lower lobe. During the next eight years symptoms increased in severity, and the patient was forced to remain away from work for four months. Three years later he had to give up work altogether, and roentgenograms showed advanced bronchiectasis, with extensive mottling throughout both lung fields (cf. figures reproduced in paper).

H. M. V.

The Threshold Toxicity of Gasoline Vapour. DRINKER, PHILIP, YAGLOU, C. P., and WARREN, MADELINE FIELD. *J. Indust. Hyg.*, 1943. Vol. 25, No. 6, pp. 225–232, 1 fig. (7 refs.).

Experiments by the Bureau of Mines showed that 0·1 per cent. of gasoline caused mild symptoms of giddiness in 50 minutes; 0·3 per cent. caused slight irritation of the eyes in 30 minutes; 0·7 per cent. caused coughing, unsteadiness and marked irritation of the eyes and nose in 10 minutes. In the present investigation two gasolines were used: (a) ordinary commercial gasoline, and (b) the volatile fraction distilled below 110° C. Experiments were made on 31 subjects in all, and were carried out in an air-conditioned chamber, 16 ft. by 22 ft. by 9 ft., at an average temperature of 74° F. At the low concentrations the subjects were exposed to the gasoline for 8 hours. A concentration of 0·027 per cent. caused 5 out of 13 male subjects to experience cough, and 9 of them to have irritation or itching in the eyes. A concentration of 0·016 per cent. caused cough in 4 out of 8 women, and irritation of eyes in 4 of them. Tests at higher concentrations of gasoline lasted 1 hour, and in that time 0·05 per cent. caused very little effect, but 0·09 per cent. caused irritation of nose, throat and eyes in most subjects, whilst 0·26 per cent. caused mild intoxication in all the 6 subjects tested. A concentration of 1·07 per cent. caused nose and throat irritation in 2 minutes and intoxication in 4 to 7 minutes, this latter effect being identical with that produced by alcohol and ether. Experiments with 1 per cent. of gasoline distillate caused intoxication but very little irritation of eyes and throat.

H. M. V.

Control of Welding Hazards in National Defence Industries. A Bulletin issued by the U.S. Department of Labour. *Welding*, 1943. Vol. XI, No. 12, pp. 499.

The production of battleships, submarines, ships of all kinds, tanks, cars, and many other vital items of equipment, is very considerably increased and improved

by modern welding methods. This Bulletin has therefore been prepared by the U.S.A. Department of Labour in order that the health hazards of welding should be widely known.

The main hazards are as follows: (1) Eye injuries from the effects of brilliant light of the arc. (2) Burns of the skin from the arc, or burns from molten metal. (3) Burns from handling hot objects such as wires, tools and rods. (4) Illness caused by welding without adequate ventilation, e.g. metal fume fever, metal poisoning.

Eye Injuries. The visible rays emitted from the flame or arc are too bright for the naked eye. The invisible rays are also harmful and may burn the skin and affect the eyes. Prevention of eye symptoms by suitable well-known devices such as goggles, helmets and face shields is not difficult amongst welders, but other persons passing by or watching the worker may get ' the flash,' the word used to describe eye symptoms, unless they also use a protective screen.

Burns. A burn from the arc may be painful and is comparable to screen sunburn. It can be prevented by covering the skin with material which will not transmit ultra-violet radiation. The accident rate from this type of burn is low. Oxy-acetylene welders should not wear oil-soaked clothing, and compressed oxygen should never be used to ventilate or ' blow out ' a tank or other confined space. Oxygen under pressure may react violently on contact with oil or grease, and clothing ignites and burns more vigorously in oxygen enriched atmospheres.

Gases, Fumes and Smoke. The harmful substances generated in welding and cutting consist (1) of gases, chiefly oxides of nitrogen formed by the effect of the intense heat upon gases which occur naturally in the air, and (2) microscopic particles in the form of fumes and smoke, particles, for example, of iron oxide, manganese dioxide, or zinc oxide from galvanized welding. In addition, welding rods are usually coated with materials which form a protective layer of gas around the flame and thus reduce the oxidation of metal. This protective coating burns and the products of its combustion rise and mix with the metallic smoke. Another source of fume is found in the oils and other protective coating, such as lead, on the metal being welded.

Metal Fume Fever. Among brass-founders and welders who handle galvanized metal and those engaged in brass or bronze welding (brazing) it is well known that breathing the yellow-blue smoke generated may cause attacks of the ' brass shakes,' ' zinc shakes,' or 'galvo,' as it is variously known amongst workers in the U.S.A. Among welders the cause of the fever is usually the breathing of zinc oxide in the form of typical welding fume.

Metal fume fever is a temporary condition usually passing off in a few hours. There is no evidence of any resulting permanent injury. Prevention lies in removing the fumes at their point of generation by means of local exhaust ventilation or otherwise.

Metal Poisonings. If pipes or other metal work covered with lead as a paint or other coating are cut by a gas or electric welding torch the resulting smoke will contain fine particles of lead and lead oxide. Similarly, if cadmium-coated materials are cut the air around may contain toxic cadmium oxide which is toxic. Prevention is also possible by suitable exhaust ventilation.

Control of Gases and Fumes. Local exhaust ventilation is the best way to prevent the inhalation of potentially harmful gases and fumes. Satisfactory systems use at least 3-inch diameter flexible metal hose. Suction fans or blowers are useful adjuncts. In confined spaces it may be necessary to use general ventilation rather than local exhausts. Satisfactory results are achieved by keeping the fume concentration below 30 mgm. per cubic meter. Ventilation rates which will accomplish this result are as follows:

	Exhaust ventilation rate in cubic feet per minute per welder
Steel electrodes—	
$^5/_{32}$ inch	250
$^3/_{16}$ inch	400
$^1/_4$ inch	700
$^5/_{16}$ inch	1200
$^3/_8$ inch	1500
Alloy electrodes (fluoride coated)—	
$^5/_{32}$ inch or less	250
Galvanized plate—	
$^5/_{32}$ inch	1000–1500

Use of Respirators. On short jobs or where neither general nor local ventilation can be conveniently applied the welder must wear an approved respirator or air-supplied mask specially designed for protection against welding gases and fumes. Air-supplied masks worn beneath the welding helmet are available, and suitable respirators can be worn with welding goggles. In either case the device should be comfortable and should not interfere with the use of adequate eye protection.

D. S.

BOOK REVIEWS

ANNUAL REPORT, H.M. CHIEF INSPECTOR OF FACTORIES FOR YEAR 1942

(H.M. Stationery Office, London. September, 1943. Cmd. 6471. 9*d*.)

The Chief Inspector, Sir A. W. Garrett, states that from his point of view the outstanding factor of the year 1942 has been the growing importance of the work of women in factories. The new type of women coming into industry for the first time, and the interest of women generally throughout the country, has led to a remarkable stimulation of public opinion for better factory working conditions.

Other matters occupying the attention of Factory Inspectors have been overcrowding, ventilation, lighting, the provision of amenities in buildings never designed for factory purposes, the health problems of luminising * and the risks of magnesium explosions. Pressure of space has required many subjects to be dealt with only in brief, or even omitted, and it has again been found impossible to include the usual statistical tables.

Accident Prevention

During 1942 the total number of reportable accidents increased, but fatal accidents showed a drop from 1646 in 1941 to 1363. The total figures, including fatal cases, are given in the following tables:

REPORTABLE ACCIDENTS (FATAL AND NON-FATAL)

Year	Adult Males	Adult Females	Male Young Persons	Female Young Persons
1938	134,752	14,626	22,922	7,803
1939	146,417	17,029	22,364	7,665
1940	173,228	23,766	26,492	8,493
1941	191,343	42,857	27,757	9,341
1942	203,865	71,244	29,028	10,493
Percentage increase over 1942 over 1938 ..	51%	389%	27%	34%

Amongst the causes of the increase as a whole are: the marked increase in employment of women and girls in the accident-producing industries; rapid acceleration of production combined with increased war weariness; increased demands on supervising staffs; the increasing age of male workers employed; less maintenance staff; and an increase in sickness rates.

Industrial Health

Dr. E. R. A. Merewether prefaces his section of the Report with the observation that because of the marked increase in the national effort we might look for evidence of lowered vitality accompanied by an increase in industrial sickness. In his view, however, no such evidence is forthcoming; but the importance of further investigations into minor non-disabling sickness is stressed.

At the end of 1942 there were approximately 850 medical officers employed in factories, just under 19 per cent. being whole time, and approximately 7 per cent. were women. At the same time there were roughly 4000 hospital-trained nurses. This figure has risen (September, 1943) to about 6000, of whom over 63 per cent. are State registered.**

In connection with medical supervision tribute is paid to the medical service of the Ministry of Supply, which has been responsible for maintaining the health of the largest group of workers in this country under one management.

There was a slight rise in the cases of lead poisoning notified in 1942 as compared with 1941, which was the lowest figure so far recorded.

The incidence of T.N.T. toxic jaundice in this war is only approximately 19 per cent. of that in the last war, in spite of greater production. The improvement continues.

There was a further reduction in the number of notified cases of epitheliomatous ulceration—113 (8 fatal) as compared with 128 (11 fatal) in 1941.

The number of cases of chrome ulceration was 89 as compared with 103 in 1941.

The reported cases of gassing show a slight reduction on the figures for 1941, being 776 as compared with 782; 220 of these were due to nitrous fumes. The number of cases which proved fatal were 25 as against 41 in 1941.

Dr. Merewether finally refers to the work of his predecessor, Dr. J. C. Bridge, who had retired from the post of Senior Medical Inspector in December, 1942, after holding it for 16 years. The promotion of industrial health in this country had been in a large measure due to his initiative and foresight in detecting matters potentially harmful to health, in particular the pneumoconioses, toxic solvents, and the effects of radio-active substances.

Hours of Employment

The work of controlling the hours of employment of women and young persons had been a major responsibility of the Factory Department. In the flour-milling industry a new General Order was made in view of the need for shift working by women and young persons over 16 in the increasing number of cases in which they were being substituted for men in this industry. The Hours of Day Work in Factories Order was issued early in the year to allow employment beyond 48 hours up to a maximum of 55 hours in certain industries. Under the General Emergency Order for Engineering the number of permissions to increase hours showed a considerable increase over 1941. At the end of 1942 permissions were in force in 13,266 factories as compared with 9129 at the beginning of the year.

The tendency during the year was towards the reduction of the weekly hours, not only of women and young persons, but of adult men whose hours are not controlled by the Factories Act. An outstanding feature has been the increase in the number of part-time workers, the majority of whom are women with household responsibilities and ' retired ' men and women who have come back to work for the period of the war.

Canteens

There has been a remarkable growth both in the number of canteens in operation at factories and in the value and efficiency of service given in them. The

* S. R. & O., 1942, No. 203, and 1943, No. 1053.

** It was reported in *The Lancet* on November 6, 1943 (p. 585) that analysis of nurses' registration forms showed that there were 8389 nurses employed in industry, of whom 185 were men. About half were on the general or one of the supplementary parts of the State Register.

following comparative table illustrates the growth of canteens during 1942.

	December, 1941	December, 1942
(a) Factories employing over 250 persons and subject to the Factories (Canteens) Order, 1940	2814	4026
(b) Factories employing over 250 persons and not subject to the Factories (Canteens) Order, 1940	351	314
(c) Factories employing under 250 persons	2530	4141
	5695	8481
(d) Docks	110	160
(e) Building site canteens ..	787	868

In addition, at the end of 1942, 411 places were known to have canteens in preparation. As in earlier years, there was little need to use legal powers of direction under the Factories (Canteens) Order, 1940, and only 69 directions were issued in 1942.

The Report states that there has been a noticeable awakening of public interest in the problem of the right use of available foodstuffs, and this is reflected by the appreciation, both of workers and managements, of the value of good cooking and sensible menu planning in relation to health and efficiency. D. S.

HEALTH AND INDUSTRIAL EFFICIENCY. SCOTTISH EXPERIMENT IN SOCIAL MEDICINE

(H.M. Stationery Office, London. 1943. Pp. 56. 1*s*.)

This Report covers four different subjects and is produced by the Department of Health for Scotland. The story of these experiments is the collective work of a team of workers under the leadership of Dr. Andrew Davidson, Chief Medical Officer to the Department.

1. *An Investigation into Long-term Incapacity for Work*

In Scotland, sickness experience of the insured population has been analysed in detail since 1930. During the year July, 1937, to June, 1938, the recorded incapacity for work was 14·08 days per person in an estimated insured population of 1,838,000, or about 37 per cent. of the population. The figure for the previous year was 14·92.

Incapacity which continued throughout the whole of the statistical year was responsible for 43·8 per cent. of the total, compared with 42·1 per cent. in 1936–7, 31,044 insured persons being continuously unfit for work of any description.

Male sickness rates varied as follows: age group 20–24, 6·21 days; age group 50–54, 20·39 days; age group 55–59, 26·45 days; age group 60–64, 37·30 days. This was roughly paralleled in the case of single women. Amongst married women the rates were dominated by conditions associated with child bearing.

The chief causes of this mass of long-term incapacity were mental and nervous diseases, rheumatism and diseases of the respiratory and circulatory systems. Many of these cases were long past any hope of reabsorption into industry.

An attempt has been made in Scotland to tackle this serious problem by reviewing the illnesses of insured persons as they came to be of three months' duration to see whether anything could be done to help the patient and to preserve his capacity for work.

2. '*The Clyde Basin Experiment*'

With war came increasing recognition of the importance of preventing the breakdown of workers, especially of young workers. With this in view the 'Clyde Basin experiment' was launched at the beginning of 1942. General practitioners and industrial medical officers were invited to refer for further investigation young workers about whose health they were concerned. In its early stages the experiment was confined to workers under 25 years of age and to the densely populated Clydeside area. Patients so referred were examined by consultants and admitted to E.M.S. hospitals for further investigation where necessary. Patients requiring convalescence to prevent breakdown were sent to one of the country houses being used as auxiliary hospitals in the Emergency Hospital Scheme.

Many cases were found to be suffering from conditions of debility and vague ill-health that so severely prejudice well-being and working efficiency without necessarily causing complete breakdown and absence from work.

The experiment has been a great success. In a year it had dealt with some 1400 young people, and then was extended to cover workers of all ages in the entire Scottish industrial belt. By the end of June, 1943, 4126 cases had been dealt with.

The following considerations emerge from a review of the scheme: (1) The need for such facilities. (2) Too many workers with fatigue carry on until unfit for work and the period of incapacity is therefore prolonged. (3) Much of the vague ill-health was due to long hours of work, travelling difficulties and inappropriate diet. (4) The vast majority of patients sent for convalescence benefited by the rest and change provided. (5) Removal of fear of disease by complete medical overhaul expedited recovery. (6) Hospital reports must be of value to general practitioners. (7) The number of cases with early organic diseases was small. (8) It was not easy to arouse enthusiasm for a scheme so essentially preventive in its approach.

3. *Socio-Industrial Problems following Discharge from the Services*

A preliminary survey in 1941 of 300 men and women invalided out of the Services had shown that, left to themselves, these people fared badly socially, medically and in relation to work. The majority required medical care, and six months after discharge 27 per cent. were still unemployed. Of those in employment only one-third had gone back to their old work.

In 1942 a more extensive follow-up of 1000 consecutive cases was carried out, based on the Interim Scheme of the Ministry of Labour for the training of the disabled. Some facts elicited were as follows: 637 of the men (and women) required care from their own doctors and 153 required hospital treatment; 161 were unemployed; 389 had gone back to their own work; 382 had taken up new work without training; and 43 with training; 257 returned to their old employer, some to do lighter work; 256 made false starts at work at which they were unable to continue; 360 reported 'difficulties' at work; and in 188 cases it was found necessary to take serious exception to the nature of the work done, for medical reasons.

4. *The Gleneagles Fitness Centre for Miners*

This is an experiment in rehabilitation. At the request of the Ministry of Fuel and Power and the Miners' Welfare Commission, part of Gleneagles Hospital (previously Gleneagles Hotel, converted to an E.M.S. hospital since 1939) was made available at the beginning of 1943 for use as a Fitness Centre for miners. The aim of this centre is to get sick and injured miners back to their work in the pits at the earliest possible moment. It provides physio-therapy, occupational therapy, remedial exercises, and physical training in a residential centre with good recreational facilities.

The Report states that it is too early to assess the value of this work, but the following results were obtained during the first six months: 390 applications for admission were received; 32 were refused as unsuitable and 24 after being accepted did not turn up; 314 cases were admitted, 89 medical and 225 surgical. Of the 184 that were discharged during this period, 111 were

fit for their former employment, 30 fit for light work, 7 unfit for any work, 6 found to be unsuitable for rehabilitation, 20 referred back to hospitals and 5 left before completion of treatment. There seems to be little doubt from the enthusiasm of patients that this centre meets a real need and is in fact a valuable complement to existing health services. D. S.

THE PRINCIPLES AND PRACTICE OF INDUSTRIAL MEDICINE

Edited by Fred. J. Wampler, M.D.

(The Williams and Wilkins Co., Baltimore. 1943. Pp. 579. 33*s*.)

This book covers the field of industrial medicine in the U.S.A. in a series of chapters or monographs written by thirty-three different contributors.

Chapters are devoted to the appraisal and control of industrial health hazards, industrial accidents, the layout of the factory medical department, the effects of temperature and humidity, lighting, fatigue and the commoner occupational diseases including dermatitis. There are sections on physical examinations in industry, venereal disease control, on what industry can do to improve nutrition, the care and prevention of eye injuries, traumatic shock and burns, the industrial back, and the nurse in industry.

In addition vocational and industrial rehabilitation is discussed, and there are chapters on compensation, occupation and tuberculosis, women in industry, and industrial medical services for the smaller plant.

D. S.

OUTLINES OF INDUSTRIAL MEDICINE, LEGISLATION AND HYGIENE

James Burnet, M.D.

(John Wright & Sons, Bristol. 1943. Pp. 87. 7*s*. 6*d*.)

The author states that this short book does not presume to be a treatise on the subject with which it deals. He intends it to be solely an introduction to further studies in this branch of medicine.

The book is divided into three parts. Part I deals briefly with industrial diseases, covering the subject in less than fifty short pages. Part II covers industrial legislation such as the Workmen's Compensation Acts and the Factories Act. Part III consists of six pages dealing with industrial hygiene. D. S.

A STUDY OF ABSENTEEISM AMONG WOMEN

Industrial Health Research Board Emergency Report No. 4

(H.M. Stationery Office. 1943. Pp. 12. 2*d*.)

This investigation was undertaken by the Industrial Health Research Board at the request of the Ministry of Supply. It is a short-term inquiry concerned with the amount and distribution of absenteeism amongst women, rather than with its causes. The Board states: 'Despite the restricted scope of the investigation, the results are considered sufficiently interesting to merit publication, and it is hoped that the work may serve as a guide to similar investigations in other war factories.'

The main conclusions are as follows. Absenteeism was not regularly recurrent, for example each week, but was as varied as the individual needs and desires of the women concerned. Married women tended to have more longer and fewer shorter absences than single women. Absenteeism on the morning shift was higher than on the afternoon and night shifts. (The two factories investigated were on the three-shift system.) It varied on different days of the week, being highest on Saturday and low on pay-day. Women up to 25 years of age lost more time than older age groups. The results suggest that attempts to reduce absenteeism should be directed to single shift and to full week absences, the latter being due mainly to sickness. D. S.

MANUAL OF INDUSTRIAL HYGIENE

Edited by Wm. M. Gafafer, D.Sc.

W. M. Saunders & Co., Philadelphia and London. 1943. Pp. 508. 18*s*.)

This book is the combined effort of sixteen authors, all of them experienced in this branch of medicine in the U.S.A. It is divided into three main parts—organization and operation of facilities; prevention and control of disease in industry; and the manpower problem.

The first part consists of chapters devoted to the organization of health services in industry, referring specially to war conditions. It includes sections on nursing and dental services. An interesting part is that devoted to a description of the available services in industrial medicine and hygiene in the U.S.A.

Part II is the longest section of the book and is devoted in the main to occupational diseases, medical control of respiratory diseases and venereal disease, industrial psychiatry, health education, the causes and control of industrial fatigue, and nutrition in industry. Chapters are also devoted to plant sanitation, and the problems of heating, lighting and ventilation are discussed at some length.

Part III is devoted to information on the maximum use of manpower, referring specially to war-time conditions, to the problems of women in industry, and to the causes and prevention of absenteeism.

D. S.

SUMMARY REPORT BY THE DEPARTMENT OF HEALTH FOR SCOTLAND

(H.M. Stationery Office. Cmd. 6462. 1943. Pp. 20. 4*d*.)

This is the third war-time summary prepared in place of the usual fuller annual reports of peace-time by the Department of Health for Scotland. It covers the activities and interests of the department for the year ended June 30, 1943.

The standard of health in Scotland remains at a satisfactory level. Reasons given are the efficient health services built up since the last war; the nutritional basis of the food rationing and other schemes of the Ministry of Food; the ready availability of employment; and the increased purchasing power of the working classes. The mild weather of the winter of 1942–3 was also a contributing factor.

The incidence of pulmonary tuberculosis, however, continues to increase. Measures taken to check this disease include the allocation of more hospital beds; arrangements for miniature mass radiography; and the provision of money allowances to encourage patients to undertake treatment at an early stage.

Substantial progress has been made in the development of plans in the spheres of housing, health, social services and town and country planning. Meanwhile such limited opportunities as are available in war-time are being taken to improve housing conditions and to maintain progress in the development of health measures.

D. S.

PROCEEDINGS

ASSOCIATION OF INDUSTRIAL MEDICAL OFFICERS

(*Founded 1935*)

Office Bearers for 1943–4

CHAIRMAN: Dr. J. C. Bridge, C.B.E.

HON. SECRETARY: Dr. W. Blood,
J. Lyons & Co., Ltd.,
Cadby Hall, Kensington, London, W.14.

HON. TREASURER: Dr. S. A. Underwood.

EXECUTIVE COMMITTEE: Dr. W. E. Chiesman, Dr. M. W. Goldblatt (retiring Chairman), Dr. D. C. Norris (Associate Member), Dr. R. S. F. Schilling, Dr. Donald Stewart and Dr. Catherine Swanston.

Honorary Secretaries of Groups

Birmingham: Dr. W. Jeaffreson Lloyd,
Guest, Keen and Nettlefolds, Ltd.,
Heath Street, Birmingham, 18.

Glasgow: Dr. G. Buchanan,
Clyde Navigation Trust,
39, Sawmill Road, Glasgow, W.1.

Leeds: Dr. C. Cresdee,
Imperial Chemical Industries, Ltd.,
Huddersfield.

Liverpool: Dr. J. Tarsh,
Automatic Telephone and Electric Co., Ltd.,
Strowger Works, Liverpool.

London: Dr. G. E. Graves Peirce,
L.M.S. Railway,
Euston Station, London, W.C.1.

Manchester: Dr. G. Taylor,
Ferranti, Ltd., Hollinwood, Lancs.

Nottingham: Dr. G. F. Keatinge,
The Butterley Co., Ltd.,
Ripley, Derby.

South Western: (*Bristol*) Dr. G. Laurence,
Westinghouse Brake and Signal Co.,
Chippenham, Wilts.

Tees-side: Dr. F. H. C. Beards,
I.C.I. (F. & S.P.), Ltd.,
Billingham, Co. Durham.

THE PROCEEDINGS OF THE ASSOCIATION OF INDUSTRIAL MEDICAL OFFICERS, 1943

During the past year the Association of Industrial Medical Officers has met at the London School of Hygiene and Tropical Medicine on four occasions February, April, June and October. Three meetings were held during Dr. M. W. Goldblatt's term of office as Chairman, the fourth was the first of the new Session.

February Meeting

The Chairman announced the formation of local Groups of the Association in London, Birmingham, Tees-Side, Manchester, Leeds and Liverpool. Rules for the conduct of local Groups were agreed, including financial arrangements. It was also announced that the British Medical Association, after meeting representatives of this Association, had agreed to publish a new British Journal of Industrial Medicine, and an Editorial Board was approved.

A discussion followed on 'Some Aspects of the Education of the Industrial Medical Officer,' opened by J. L. Smyth, Esq., Social Insurance Department, Trade Union Congress, and Dr. Frank Gray.

April Meeting

The Executive Committee reported on a meeting it had held with representatives of the Royal College of Nursing to discuss various matters relating to the training and status of industrial nurses. As a result of this meeting Dr. J. C. Bridge and Dr. W. E. Chiesman were elected to serve on the College's Education Sub-Committee on Industrial Nursing.

Dr. M. W. Goldblatt had accepted an invitation to join the Minister of Labour's Industrial Health Advisory Committee. The Scientific Advisor to the Ministry of Food had asked members of the Association to assist in a 'height and weight' survey of industrial workers. The suggested procedure was outlined, and members agreed to participate in this work.

A discussion followed on 'Human Problems in Industry,' opened by Dr. T. M. Ling.

June Meeting

The Chairman announced the formation of two more local groups, at Nottingham and Bristol respectively.

Dr. Chiesman was elected to represent the Association on the Research Board for the correlation of Medical Science and Physical Education.

Dr. Catherine Swanston was elected to represent the Association on the War-Time Rest Breaks for Industrial Workers National Advisory Committee.

The Chairman opened a debate on 'The Place of Industrial Medical Service in a Comprehensive National Health Service.' He stated that the Executive Committee had carefully considered this matter and had drawn up a document which he thought would serve as a basis for discussion. The various proposals would be considered separately, and where a substantial measure of agreement was reached the item would be included in a memorandum on this subject setting out the views of the Association. The memorandum would be presented to the British Medical Association, which in the matter of a Post-War Comprehensive National Health Service was acting for the profession as a whole. The main points were agreed and the Executive Committee and Group Secretaries were empowered to proceed to draft the final form of the memorandum.

October Meeting

Dr. J. C. Bridge, C.B.E., was unanimously elected Chairman for 1943–4 and 1944–5, and other office-bearers were appointed for 1943–4.

Dr. M. W. Goldblatt, the retiring Chairman, was accorded a vote of thanks for his services to the Association during his two years of office.

The Hon. Treasurer reported on the financial statement for the year 1942–3. The members agreed that the financial position of the Association was sound and the report was adopted.

The retiring Chairman reviewed the work done by the Association during the past two years.

The Hon. Secretary was instructed to write a special letter of appreciation to the Dean of the London School of Hygiene and Tropical Medicine for the kindness the authorities of the school had always shown to the Association. It was decided to send a contribution of £10 10*s*. to the Association's prize fund held by the London School. A donation of £10 10*s*. was voted to the Stalingrad Hospital Laboratory Fund.

The Chairman reported the delivery of the Association's Memorandum on Industrial Medical Service to the British Medical Association.

The private business was followed by a discussion on 'The Investigation of Toxic Hazards,' opened by Dr. M. W. Goldblatt, whose paper is published in this number (p. 20).

PROCEEDINGS OF GROUPS

BIRMINGHAM GROUP

This Group was formed on October 21, 1942, as a result of the decision by the A.I.M.O. to set up groups in the provinces. It replaced what was previously known as the Birmingham Industrial Health Group, started in February, 1942, by the whole-time industrial medical officers of Birmingham.

Meetings

October 21, 1942. Inaugural General Meeting.

November 25, 1942. 'The Essential Work Order and the Medical Referee System,' H. E. Chater, Esq., Ministry of Labour; Dr. R. Thornhill, Ministry of Health.

December 10, 1942. 'The Beveridge Report,' Dr. Donald Stewart.

December 17, 1942. 'Minor Sickness and Neurosis in Industry,' Dr. Russell Fraser.

January 27, 1943. 'Provision of Rehabilitation Centres for Sickness Cases,' Dr. J. G. Billington and Dr. J. A. Brown.

February 3, 1943. 'The Beveridge Plan and Voluntary Hospitals,' H. F. Shrimpton, Esq., House Governor, Children's Hospital, Birmingham.

March 17, 1943. 'Industrial Medical Research,' Dr. R. S. F. Schilling, Secretary, Industrial Health Research Board.

March 31, 1943. 'The Future of Industrial Medicine,' Dr. Donald Stewart.

May 12, 1943. 'The Beveridge Plan and Workmen's Compensation,' A. S. Barnfield, Esq., Midland Employers' Mutual Assurance Company; Councillor C. G. Spragg, Birmingham Trades Council; and Dr. N. T. Glynn.

July 7. 1943. 'The Structure of Industry—with some thoughts on the well-being of the worker,' J. H. Jolly, Esq., Managing Director, Guest, Keen and Nettlefolds, Ltd.

August 25, 1943. Film on the work of a psychiatric rehabilitation centre (Mill Hill E.M.S. Hospital), Dr. Russell Fraser. Joint meeting with the Birmingham Industrial Nurses' Group.

Action taken by the Group

(a) Demand by nurses has led to the institution of a Certificate in Industrial Nursing granted by the University of Birmingham. Members of the Group take an active part in the theoretical and practical training.

(b) Conference between the Group, the Regional Hospitals Council, and the Birmingham Eye Hospital has led to improved out-patient facilities for factory workers at this hospital and the appointment of a whole-time senior accident surgeon.

(c) Collaboration in the Medical Research Council's investigation (by Dr. Russell Fraser) into the incidence of minor illness and psychoneurosis in industry.

(d) Collaboration in the Medical Research Council's investigation (by Professor A. A. Miles and Dr. R. Williams at the Birmingham Accident Hospital) into the problems of wound infection in industry.

(e) Institution of courses of training for factory nurses at the Eye Hospital. Special short courses of practical training lasting 3 hours a day for 12 successive days, were started on June 7, 1942. Three or four nurses attend each course.

LEEDS GROUP

The inaugural meeting was held at the Algernon Firth Institute of Pathology on January 30, 1943. It was found that there were about twenty members of the Association in the south of Yorkshire, but owing to the present difficulties in travelling few of these would be able to attend meetings.

At this opening meeting rehabilitation was discussed and it was agreed that this was an urgent matter which could only be dealt with nationally. Among other matters discussed were certain problems concerning the ethical code for industrial nurses.

On February 27, 1943, a meeting was arranged to debate the Tomlinson report, but owing to many members being unable to attend this subject was held over until a later date, and a discussion on matters of general interest followed. Methods of accident recording, health among spray-painters, and the use of hot-air hand-driers were among the subjects raised.

On May 1, 1943, a special meeting was held to consider the place of an industrial medical service in post-war medical schemes, and certain resolutions were forwarded to the Executive Committee in London. Mr. A. B. Pain, F.R.C.S., was the guest at this meeting and replied to questions regarding co-operation between industrial medical officers and hospitals.

LIVERPOOL GROUP

A meeting took place at the Automatic Telephone and Electric Company on February 11, 1943, of doctors who were engaged full-time and part-time in industrial medicine in the Merseyside area. This resulted in the formation of a Liverpool (Merseyside and District) Group under the auspices of the main Association. Owing to the transport restrictions during war-time it was decided that meetings should be held quarterly at which papers of industrial medical interest should be read by both individual members and invited speakers, and afterwards discussed.

The second meeting of the Group was held on March 19, 1943, when a discussion took place on the position of industrial medicine in a comprehensive medical scheme as envisaged in the Beveridge Report. It was decided that the Secretary should draw up a questionnaire on the subject and that further debate should take place at a later meeting.

It was reported that discussions had taken place

with the Liverpool Panel Committee to initiate improved methods of co-operation between industrial medical officers and general practitioners in the area.

The third meeting of the Group was held on May 14, 1943. A full discussion took place on the questionnaire, which had been drawn up by the Hon. Secretary and circulated to all members, on the place of an industrial medical service within a comprehensive medical service for the country. The conclusions reached were forwarded to the Secretary of the Association of Industrial Medical Officers.

The fourth meeting took the form of a visit to Messrs. Pilkingtons, Limited, St. Helens, on August 18, 1943, at the invitation of Dr. R. Morris Jones, Medical Officer to this firm.

An industrial medical service had been in operation here for many years, and within the last two years a mass radiography unit had been augmenting preplacement examinations. The local Medical Officer of Health co-operated fully in these investigations and took over the treatment of cases of pulmonary tuberculosis so discovered. The x-ray films exhibited showed the incompleteness of clinical examinations without radiography.

At the firm's rehabilitation centre, recently started, over twenty employees were seen undergoing remedial exercises and organized games, under the direction of a qualified instructress and supervised by the medical officer.

A tour of the works afforded the visiting doctors some understanding of the conditions to be endured when working conditions necessitate high temperatures. The hazards in the manufacture of glass were minimized by the provision, for all operatives, of clothes specially designed to protect the vulnerable parts of the body.

LONDON GROUP

The London Group was formed at a meeting held at the London School of Hygiene and Tropical Medicine, Keppel Street, W.C.1, on October 28, 1942, under the chairmanship of Dr. M. Dobbie-Bateman. The hospitality of the School of Hygiene for meetings was offered by the Dean, Col. G. S. Parkinson, D.S.O.

Meetings

November 18, 1942. 'Problems presented by Men Invalided from the Forces,' Sir Henry Bashford.

January 6, 1943. 'Dermatological Problems in Industry,' Dr. I. Muende, Dr. Sibyl Horner, and Dr. A. J. Amor.

February 6, 1943. 'The Beveridge Report,' Mrs. Anne Carr, Henry Lesser, Esq., O.B.E., Professor H. Levy, and Dr. H. B. Trumper.

March 17, 1943. 'Some Problems in the Surgery of the Hand,' R. M. Handfield-Jones, Esq., F.R.C.S.

May 5, 1943. 'The Place of an Industrial Medical Service in a Comprehensive Medical Plan for the Country,' Dr. H. B. Trumper.

June 2, 1943. 'The Place of an Industrial Medical Service in a Comprehensive Medical Plan for the Country.'

October 10, 1943. 'The Scope for Health Education in Industry,' Dr. Robert Sutherland.

MANCHESTER GROUP

The first meeting of this Group was held on December 10, 1942, in the University of Manchester. The object of the meeting was explained by Dr. R. E. Lane and it was decided that the area to be covered by the Group should, for the time being, embrace Lancashire and North Cheshire. The meetings would be held quarterly in the premises kindly lent by the University.

The second meeting was held on Thursday, January 21, 1943, when a paper was read by Dr. T. S. Scott on 'The Relationship of the Works Medical Officer, General Practitioner, Surgeon and the Hospital,' followed by Dr. Rowland Nightingale.

The third meeting of the Group was held on Wednesday, April 21, 1943, and at the request of the Executive Committee of the parent body the subject chosen for discussion at this meeting was 'The Future Place of Industrial Medicine in the Country's General Medical Services.' Papers on this subject were read by Dr. Donald Stewart and Dr. W. E. Chiesman. Following this meeting a memorandum was forwarded to the Executive Committee expressing the views of members.

The fourth meeting took the form of a visit to a Health Exhibition which Dr. Lane had been responsible for instituting at the Chloride Electrical Storage Co., Ltd., Clifton Junction.

Dr. Lane said that this was probably the first actual Health Exhibition which had been held in a works under the auspices of its management. He explained the purpose of the Exhibition as primarily to educate the workers concerning the simple methods of maintaining their health, and to demonstrate the precautions that were taken by the firm to prevent ill-health and disease.

The exhibition consisted of well-balanced and constructive propaganda dealing with the health of the worker during his 24-hour life cycle. It was divided into the following main sections: ante-natal work, dental treatment, safety devices as distinct from health hazards, health hazards due to specific employment, and blood transfusion services. Each section was under the charge of a monitor who had to explain the purpose of his section and what the exhibits were intended to convey. The sections were illustrated by clear and well-designed photographs and posters, and five-minute 'pep' talks were given over the broadcasting relay system in the works each day on a particular subject illustrated in the exhibition.

The exhibition also urged parents not to encroach on their children's rations, and stressed the importance of adequate vitamins in childhood for the pre-

vention of rickets and malnutrition, and the need for control of diseases such as scabies and pediculosis.

The exhibition was a greater success than had been anticipated and it was well supported by the workers who viewed it in their own time. Much thought, patience and ingenuity had been put into the formulation of this exhibition, and any firm that considered holding a similar exhibition had a good example to follow and a high standard to maintain.

NOTTINGHAM GROUP

The Nottingham Group of the Association of Industrial Medical Officers was formed in April, 1943.

The first meeting took place on May 27, 1943, when Dr. T. A. Lloyd Davies read a paper on 'The Medical Aspects of Safety.'

The second meeting was held on September 15, 1943, the address on this occasion being given by Dr. A. J. Amor, Chief Medical Officer, Ministry of Supply, on 'Some Medical Problems in the Explosives Industry.' Members of the Nottingham Medico-Chirurgical Society were invited as guests and joined in the discussion which followed.

Further activities planned for the future include a visit to Messrs. Boot's Day Continuation School, and an address by Dr. E. R. A. Merewether, H.M. Senior Medical Inspector of Factories.

SOUTH WESTERN (BRISTOL) GROUP

This Group was formed on May 15, 1943, covering the south-western part of England and based on Bristol. There was an initial membership of sixteen.

A subsequent meeting was held on June 15, 1943, in the Recreation Hall of Messrs. W. D. and H. O Wills, which had been generously placed at the disposal of the Group by this firm. The business discussed related to the future of industrial medicine and a memorandum was subsequently submitted to the Executive Committee through Dr. G. R. A. Armstrong.

TEES-SIDE GROUP

The Tees-side Group of the Association of Industrial Medical Officers was formed from the Tees-side Industrial Medical Society. The first meeting of this Society was held on August 13, 1942, at Billingham. There were eleven original members, and meetings were held monthly until March, 1943, when the Society became a Group of the Association with additional members.

The following meetings have been held.

September 24, 1942. A discussion on 'The Functions of an Industrial Medical Service' was opened by Dr. F. H. C. Beards.

October 22, 1942. A discussion on 'The Relationship between the Industrial Medical Officer and other Practitioners' was opened by Dr. H. Fallows.

November 25, 1942. A discussion on 'Standards of Physical Fitness for Employment' was opened by Dr. J. W. Ridley. Dr. Ridley suggested that, owing to the increasing mechanisation of modern industry, mere physical strength was becoming less of a requisite in workers and that good physique was not necessarily, *per se*, an indication of good health. He stressed the sociological importance of admitting entrants with slight physical defects to carefully graded work. He thought the simple method of conversation was often preferable to others in assessing intelligence. He dealt with certain particular disabilities in association with special employments and emphasized the importance of accurate accident records in order to demonstrate subjects of accident proneness.

January 20, 1943. A discussion on 'Ventilation in Industry' was opened by Dr. D. T. K. Harris. After dealing with the questions of cubic space per worker in normal and toxically hazardous occupations, Dr. Harris supported the view that undue heat, moisture content, and lack of movement were the principal factors in ordinary vitiations of air; that the problem was mainly physical and not chemical, cutaneous and not respiratory, and quoted experiments in support of this; and he discussed the question of working-room temperatures and humidity.

February 17, 1943. A discussion on 'Eyesight Factors in Industry' was opened by Mr. A. E. P. Parker, from the point of view of illumination, the eyes themselves and their protection from injury. He advocated the testing of vision for all new entrants into industry and suggested as a topic for research the relation of amblyopic eyes to accident proneness. He thought that the great majority of eye accidents were easily preventable and that education was urgently required, particularly in respect of wearing goggles in certain industries. He also stressed the great importance of early attention in all cases of corneal injuries, however seemingly slight.

March 17, 1943. A discussion on 'Sick and Injured Workers, their Rehabilitation and Resettlement,' was opened by Dr. R. W. Murphy. He maintained that rehabilitation should be kept in view, in accident cases, from the first moment of first-aid treatment in the factory.

April 22, 1943. At this meeting two local Trade Unionists attended by invitation and opened a discussion on 'The Trade Unions' views on Industrial Medicine and Industrial Medical Services.'

October 13, 1943. Inaugural meeting of new session held at the Metropole Hotel, Stockton-on-Tees. It was decided to hold future meetings as follows: Tuberculosis in industry; orthopaedic surgery in relation to industry; radiology in connection with industry; and skin diseases in relation to industry. The local Medical Inspector of Factories would also be invited to open a discussion on a subject of his own choosing.

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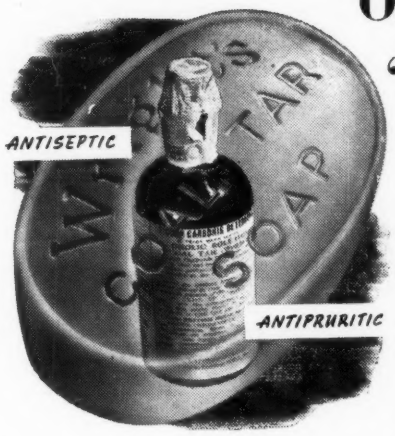

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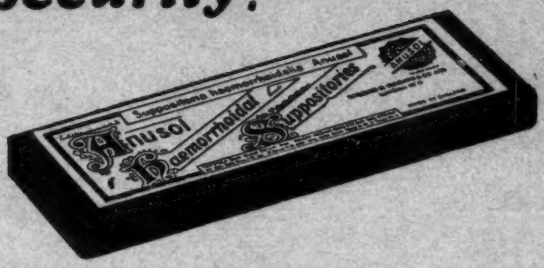

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THE TRAINING OF THE INDUSTRIAL NURSE

BY

A. J. AMOR and CLARE SYKES

London

War has brought an extension and speeding up of technical and professional education in this country which has gone largely unobserved because there has been no time for comprehensive surveys. Probably it has been excelled only in the Russian experiment which set itself to produce from an illiterate and peasant populace a large proportion of industrial workers, mechanics, skilled engineers, teachers, doctors and administrators, and to do so within a strict time limit. While our relatively long industrial history and system of state education spared us the stark immensity of Russia's problem, total mobilization of man- and woman-power to the urgent needs of war required of us something of the same swift transition to new occupations; occupations, moreover, which demanded an exact technical competency. A man employed as a casual labourer in 1939 controls a nitrating plant in 1942. Thousands of former shop girls and domestic servants are now not merely doing repetitive machine jobs in aircraft, munition and engineering factories, but also highly skilled precision work. Thousands of clerks, salesmen and insurance agents have become R.A.F. pilots. Many professional men and women have been required for new specializations, or specializations presenting new problems in the stresses of modern war, as for naval, aviation and industrial medicine. Here specialized post-graduate courses must be added to the basic professional training. A study of the new environment and its problems is required and the development of skill in adapting professional knowledge to a new field of application.

Of necessity, leisurely and carefully graduated apprenticeship has been swept away. All has been done by means of the 'Short Training Course,' on which 'Urgent' has been stamped. In the industrial field the 'Government Training Centre,' originally a small-scale and somewhat inconspicuous attempt to deal with one aspect of an unemployment problem, has since 1939 been inconspicuous for the new reason that practically every large factory, and particularly those in the aircraft and munition industries, has its own 'Training Centre,' or 'Training Shop.' Syllabus, methods and practice have been governed by two considerations and two only—adequate technical competency in the shortest possible time. The short war-time course is intensely practical; 'you need to know this because you have to use it.' General principles and theory are cut to the essential minimum. Those short courses, designed for professional groups whose vocational education under normal conditions would include a good deal of 'background study,' have perhaps suffered most by the necessary effort to pass out the greatest number in the shortest time. But this bias towards the severely practical, even in the professional sphere, has not been wholly disadvantageous. It has at least compelled us to question our aims and methods and this has been particularly valuable in such a comparatively new specialization as industrial nursing, where, because of the variability of industrial organization, because of the isolation in which the industrial nurse works, particularly in the smaller factories, and the fact that neither her employer nor herself, on her first entry to the factory, can appreciate the exact scope of her duties, clarification has been groping, slow and experimental.

It is first necessary to determine precisely for what we are training the nurse, what will be the scope of her actual duties and responsibilities and the professional and personal qualifications these demand. We have then to determine what skill and what theoretical knowledge are necessary to meet these demands and what type of educational organization, what teaching staff and what practical experience can best provide them. It is equally important that we are clear on these fundamentals, whether we consider war-time 'short courses' or the longer post-graduate courses which we may hope to see re-established after the war. A post-graduate training course is designed not only to impart a certain amount of knowledge but has also to give the nurse an orientation to her work and to condition her to a new environment. A factory medical department is not to be considered an annexe or a sort of 'out-post' of hospital practice; it should be an integral part of factory organization and will achieve its purpose only in so far as it succeeds in becoming so. While the implementation of this policy is primarily the responsibility of the directional head of medical service within the factory, it must be fully understood and appreciated by every member of the medical and nursing team. Hence it follows that while certain aspects of the nurse's

industrial training will take place within a hospital, as special casualty training with an emphasis on the early stages of rehabilitation, or in ophthalmic treatment, fracture and skin clinic work, yet her main teaching centre and practice ground must be the factory itself.

Duties and Responsibilities

An experienced industrial medical officer recently stated that she demanded four qualities of her nurses; sound clinical judgment, good technical skill in the works surgery, a knowledge of the special hazards in her factory and of environmental hygiene, and an ability to get on with both workers and management. She added that 'if she has these virtues all others shall be added unto her.' These criteria probably command general acceptance amongst practising industrial medical officers and nurses and it is noteworthy that these four qualities are not less but more essential in those small factories where a nurse has not the advantage of working under the direction of a full-time medical officer. Perhaps too much has been made of the differences between large and small factories as regards medical department organization and actual nursing duties. Apart from the fact that in the smaller factory the nurse's work, like other executives' work, tends to be less specialized and that in the absence of a full-time doctor she takes more responsibility for organization and administration of the medical department, her actual nursing duties and responsibilities are much the same. (It should be noted that where a nurse undertakes the duties of a welfare supervisor, she should have had special training in welfare supervision and that only the training of industrial nurses as such is discussed here.) On the other hand, minute variations in factory organization make it difficult to draw up any list of duties and responsibilities for industrial nurses which is universally applicable, but that issued to senior sisters in the Ministry of Supply Nursing Service may perhaps be taken as broadly representative of the duties of an industrial nurse, although even within that organization minor modifications are necessary to meet slightly varying 'set ups.'

Duties and Responsibilities of Senior Sisters Ministry of Supply Nursing Service

1. To be responsible to the medical officer for strictly medical and professional matters; to be responsible to the Superintendent for the organization and discipline of nursing services in the factory, the observance of regulations by surgery staff, and for all else pertaining to her duties. She is to be considered head of the nursing service in the factory and all matters concerning the nursing staff will go through her.

2. To organize surgery routine and ensure that nursing service covers all hours when workers (including maintenance and canteen employees) are working. To arrange such nursing supervision and participation as is necessary for entrants and other examinations and such special clinics (dental, optical, ultra-violet ray, etc.), as may be set up.

3. To be responsible for the training of nursing staff and auxiliaries in sound industrial nursing practice and for the supervision of nursing duties which are to be carried out strictly in accordance with hospital standards of technique. Special attention to be paid to the prevention of sepsis.

4. To undertake treatment of minor injuries, the first treatment of major casualties, and of sickness occurring in the factory and such subsequent treatment as may be ordered by the medical officer.

5. To be responsible for the cleanliness and orderliness of surgery premises.

6. * To be responsible for the safe-keeping of all drugs, medicines and lotions and of all surgical dressings and instruments. To supervise issue of such stores and to keep stock records. To order medical and surgical supplies in accordance with such instructions as are issued from time to time.

7. To ensure that full and accurate records of all surgery attendances are kept and any other medical records which the medical officer may place under her supervision.

8. To acquire knowledge of the nature and hazards of the process in the shops and to arrange regular and systematic visits to the shops by her nurses, having made such arrangements as may be necessary with Production and Labour Departments.

9. To do all in her power to foster and maintain co-operation with labour officers and production managers and good relationships with foremen and forewomen and all supervisory grades of production. To co-operate especially with labour officers on such matters as the placement of workers having any physical handicap, transferences for medical reasons, patients to be sent home on account of injury or ill-health and returning from sick absence, and the care of pregnant women, after discussion with the senior medical officer. To arrange that a trained nurse shall see all workers before they are sent home on account of injury or sickness at such times as the medical officer is not available.

10. To deal confidentially with individual problems of personal hygiene referred to her. To promote the education of the workers individually and collectively in matters of general and personal hygiene and with particular emphasis on such prophylactic measures as their work may render necessary. Her demeanour towards workers at all times to be courteous, friendly and accessible, yet dignified and firm.

The New Entrant to Industrial Nursing

Great attention should be paid to the need to acclimatize and condition the nurse to her industrial environment. Those of us who have always lived in close touch with industrial organization or who have long practised in industry perhaps tend to forget what a strange and bewildering new world it is to the nurse straight from hospital and how little her hospital life and organization prepares her for it. The organization of the largest hospital is relatively simple. Its main purpose is the cure and treatment of the sick, which main purpose doctors and nurses directly serve, with their work and attention focussed on the ward and its patients. The other departments and personnel which are subsidiary to the main purpose and indirectly support it, barely impinge on the nurse's consciousness and thus she tends to think the organization even more simple than it actually is. Usually it presents itself to her as two parallel hierarchies, one line running down from honorary to first-year medical student and the other (and the only one which really concerns her) running down from Matron to the last batch of probationers in the Preliminary Training

* Omitted in factories where a dispenser is employed.

School. But even the rawest probationer, from the time she enters her first ward, is in the centre of the picture. She directly serves the main purpose of the great institution and no menial jobs or snubs from her seniors can disguise it. Even at the stage where she does little more than change the bowls and hold the safety-pins for sister, she is part of the swaying drama that goes on between illness and health, life and death; she knows the tension of the operating theatre, the ambulances coming in at night, the swift preparation of ' acutes ' under the shaded lights; she may perhaps acquire some faltering insight into the strange pitifulness of human hopes and fears, ' the tears in things,' and her first experience of human tragedy.

We contrast the industrial organization and the nurse's place in it. On entering industry she passes into a world organized on quite other lines to the world she has known. A world organized for the production of goods, materials and services. A world with a comparatively static population, where the majority are not sick, where prevention is the keynote. ' Production ' is the main purpose here; the important people are those who directly serve it—managers, shop managers, foremen, chemists, engineers, operatives. She becomes aware of seemingly subsidiary departments—Administration and Wages, Research, Maintenance Services, Personnel and Medical; over all presides ' The Board ' and its Chairman with one or more Managing Directors. To the uninitiated the whole organization and the functions of its parts seem very complex, and it is encountered in a totally new environment, with new types of people talking a strange production jargon, and the rattle and vibration of strange machines. The nurse does not know quite how or where she fits in, but it seems obvious that she is not the centre of the picture here. She has been taught implicitly to follow the instructions of doctors and seniors and to observe hospital etiquette; she has not been taught the art of co-operation with a varied hierarchy of people doing completely different jobs and probably only discovers that there is such a thing as factory etiquette by an initial series of blunders, some of which may be difficult to live down. In hospital patients live under the direction of doctors and nurses. In industry the nurse discovers that whether workers use the medical department at all depends on how far its staff can establish and maintain confidence in it. She realizes that a persuasive and reasoned approach is required, which again is a new technique to her. In hospital her status was fully established, and while much progress has been made this status is still not fully established in industry. While, broadly speaking, those factors within the factory which directly influence health should come within the sphere of her influence, this is by no means accepted and she must learn to employ ' the tactics of infiltration.' No elaborate records are demanded of her in hospital nor does her work there tend to be assessed statistically by business men who habitually think in figures and work on concrete facts. She has to learn to present her work, and her results and any request she may wish to make, in such a form. Even technically she may find that she has much to learn, not only of special industrial hazards and precautions, but because her hospital training may have been weak in those types of experience especially valuable in industrial practice. The actual time spent and experience gained in ophthalmic work and in out-patient and casualty departments during or subsequent to general training is variable and may require strengthening.

Practical Background of Training

Primary training for industrial nurses must therefore provide not only lecture courses and technical demonstrations, but also survey the structure of industry and factory organization, acclimatize the recruit to factory life and conditions, and give her the best orientation possible to her own work in and for the factory community. The orientation of herself and her work must spring from an appreciation of that new philosophy of industry which pays the greatest attention to the health and welfare of those working in the factory. Whilst this philosophy is evolving slowly it had made some progress in the years prior to the war, expressing itself in the adoption of comprehensive personnel policies by the modern technique of personnel management and the establishment of industrial medical departments. As is usual in war the stimulus of production has emphasized the necessity for exercising the greatest care with the limited human forces available. It has been recognized that those industries which have been most successfully integrated and geared for maximum production have been those which have recognized the importance of the health and welfare of their workers. Thus medical and nursing service closely linked and working in fullest collaboration with the personnel department and responsible directly to the most authoritative person within the factory, is a clearly defined and functioning entity within the factory in the sense in which ' production,' ' services ' and ' research ' are clearly defined entities. If it is essential that this orientation be given to the industrial nurse and given as a fundamental faith, concretely to be worked out and demonstrated in order that she might realize the full significance of her daily work, it is equally essential that it shall be given historically and realistically. Historically, because it is an emergent philosophy, not yet accepted or practised over the whole of industry. She should be helped to appreciate the long road we have travelled from conditions in the early days of the industrial revolution, and the milestones of factory law and legislation on that road. Realistically, because she must know the worst as well as the best of factory conditions to be found in our own day. She must appreciate both how far beyond the legal minimum the best have gone and how great the effort required to keep the worst to that minimum.

These considerations lead to the conviction that the major education of the nurse must take place

within the factory and that those who are to teach must be those who have full experience of the practical side of industry. There may well be a place for more advanced and academic study, such as is envisaged in the Industrial Nursing Section of Part B of the London University's Diploma in Nursing, but the basic industrial course should be practical, and based and grounded in the factory.

Syllabus of Training

The presentation and grouping of subjects within the syllabus is important. The syllabus should not be a hotchpotch of subjects whose relation to each other and to factory organization and functions is undefined; these subjects should rather be so grouped and presented as to integrate them with actual duties and responsibilities and to give the requisite orientation to factory conditions, and they must be woven into a comprehensible pattern. A suggested outline for a primary and basic course in industrial nursing is given below. It is considered that even under war-time conditions such a course could not be completed, together with the requisite demonstrations and practical work entailed, in less than 3 months, and under peace-time conditions should preferably be spread over 6 months.

OUTLINE SYLLABUS FOR THE BASIC TRAINING OF INDUSTRIAL NURSES

I. The Structure of Industry. Machinery of Industrial Relations. The Position of Medical and Nursing Services within the Factory Organization.

(*a*) The purpose of industry: the production of goods, materials and services. Evolution of industrial organization. Company structure. Factory organization and administration, including executive control and departmental organization.

(*b*) The machinery of industrial relations:

(i) Internal: Works Councils and Production Committees. Functioning of Whitley Council in the factory.

(ii) External: Trade Unions, organization and functions. Trade Boards and National Whitley Council Organization. Employers' Federation.

(*c*) The place of the Medical Department in the factory; chain of control.

(*d*) The work of the Personnel Department and the integration of Medical and Personal Departments. Integration with other factory departments.

II. The Worker

(*a*) *Health Maintenance*

Non-scheduled diseases common amongst industrial workers: rheumatic diseases, chronic bronchitis and other respiratory affections, gastro-intestinal complaints, hernia, anaemia, communicable diseases. Interaction of the personal, social and environmental factors involved in maintaining health. The preventive and constructive side of the nurse's work.

(*b*) *Industrial Psychology*

Physical and mental aptitudes, intelligence and dexterity tests. Temperaments with special reference to the nervous. The effects of monotony, fatigue and boredom. Manual work. Weight-lifting and carrying. The place in industry of the mentally abnormal.

(*c*) *Methods of Health Education*

The teaching functions of the industrial nurse. Individual and group instruction. Methods of approach to different groups and ages. Practical teaching; preparation of talks and illustrative material; presentation to the group. Interviews and talks with new entrants. Courses of health and hygiene talks as a part of training schemes in industry.

III. Organization and Work of a Factory Medical Department

Organization

(*a*) Design and equipment of Medical Departments and surgeries in large and small factories. Medical and surgical stocks. Staffing.

(*b*) Objects and methods of compiling systematic records of sickness, accidents, occupational diseases, and monthly medical reports. Sickness rates and their interpretation. Charts and graphic methods of illustrating facts.

(*c*) Liaison with outside medical services, hospitals, public health and social services.

(*d*) Personal and professional qualifications required in industrial nursing. Industrial nursing ethics. Standing Orders. Staff supervision and training. The development of industrial medical services and associated research bodies in this country. The approach to the worker. Factory etiquette.

Functions

(*a*) Examination of new entrants: the nurse's duties working under the direction of a medical officer. Inspection and history taking; the nurse's duties if a medical officer is not available. Assessment of physical requirements for process in association with psychological requirements (see above). 'Follow-up.' Health supervision, including personal hygiene and defestation. Health supervision of special groups: (i) adolescents, (ii) workers engaged on strenuous and hazardous processes, (iii) pregnant women, (iv) elderly workers.

(*b*) Treatment of minor ailments and injuries in the factory surgery and the prevention of sepsis. Casualty surgery of major and minor injuries, including fractures and crush injuries. The first care of medical, surgical and gynaecological emergencies. Examination and treatment of eye injuries.

(*c*) Rescue work and resuscitation. Treatment of gassing cases. Heat stroke. Rehabilitation of the injured worker.

(*d*) Accident prevention—liaison with Safety Officers. Medical representation on Works Safety Committees. Accidents in relation to personal qualities and to environmental conditions.

(*e*) Auxiliary Medical Services: ophthalmic, dental and chiropody clinics. Ultra-violet light clinics.

IV. The Working Environment

(*a*) *Physical.* Lay-out of a factory; 'good housekeeping.' Heating, lighting and ventilation. Humidity. Pressure changes. Glare. Noise and vibration. X-rays.

(*b*) *Chemical.* (Treatment here includes the diseases and medical conditions these substances may cause, paths of entry of poisons, and methods of prevention and control.) Solids. Liquids. Gases. Vapours. Fumes. Smokes. Dusts.

Inorganic. Lead, mercury, arsenic, nickel, manganese, chromium, phosphorus, nitrous fumes, silica, asbestos.

Organic. Benzene and its derivatives, nitro derivatives, amida, nitrophenol, dope, tetrachlorethene, carbon disulphide, boxwood, tarpitch, etc., mineral oil, soot, dioxan, naphalenes, $CHBr_3$, tri-*o*-phosphate, tri-*p*-phosphate, cotton.

(*c*) *Biological.* Anthrax. Glanders. Ankylostomiasis. Weil's disease.

(*d*) *Psychological.* The working group. The study of the individual and the group in relation to the working environment. Mental atmosphere, social environment and discipline, people in authority. The importance of foremen and forewomen as the rank of supervision in closest and most continuous contact with workers. Anxiety and danger.

Organization and control of working conditions; advisory functions of the Medical Department. Work spells and rest pauses. Hours of work and shift systems. Night work. Systems of wage payment. Wages and the standard of living. Arrangements for transfers and promotion. Welfare arrangements and supervision; provision of amenities including canteens. Effect of working conditions upon labour turnover, absenteeism, accidents, output, health, industrial fatigue and unrest.

(*c*) *Study of the Processes of Production.* The production 'flow sheet' from raw material to finished product with the various chemical metallurgical or manufacturing processes carried out at each stage. Job analysis. Time and motion study. How to tour a factory.

V. The Law

(*a*) The minimum requirements for health, safety and welfare. The 1937 Factories Act.. War-time amendments. Special orders and regulations subsequently made.

(*b*) The specific control of a chemical process and the medical observation of the worker. Chemical Works Regulations.

(*c*) Financial provision for the diseased and injured workman. Workmen's Compensation, and Silicosis and Asbestosis Acts.

VI. The Social Background

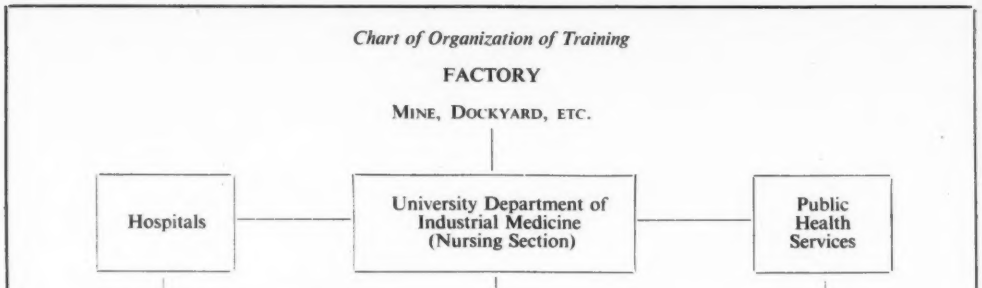
Home and social environment. Evolution of the traditional institutions of industrial workers. Recreations. The importance of appreciating the worker as a citizen with his own pattern of social life outside the factory. Social Insurance. Guide to statutory and voluntary social services; a need for a personal interpretation of these to those whom they are designed to benefit.

Need for Experienced Teachers

It has been said, and cannot be too strongly stressed, that the major education of the factory nurse must take place within the factory (including, of course, the shipyard, the mine, the dock and harbour authority, the department store), and that those who are to teach must be those who have experienced to the full the practical side of industry. Lecture rooms there must be and visiting external lecturers who are authorities in their special subjects, but these must play a part subordinate to the first-hand study and practice within the factory. The educational committee, or whatever be the body which is responsible for the organization and administration of the training, must be composed, not of the external authorities, whether of the educational or medical professions, but of practising industrial medical officers and industrial nurses, who together shall have had a wide experience in varied industries and types of firms. It is recognized that this is not an easy stipulation to fulfil; people of the requisite calibre and experience are few; and as they combine their practical duties with leadership within their specialty, their time may seem to be fully occupied. But it is believed that those who have done most to establish standards of practice in a new field are those who are most deeply concerned with the education of its future practitioners, and that if such training courses were established in industrial areas it would be possible to gain the co-operation and service within the area of both industrial medical officers and nurses and of industrialists themselves, who alone can give the 'laboratory facilities' required in the factories. To place the broad direction of the training in such hands ensures that the practical requirements and problems of a works medical department shall be kept well to the fore and practice and theory closely correlated, that so far as possible a uniformly good standard of practical instruction and demonstration is given and sound proportion maintained in combining the different parts of the syllabus.

Probably we must look to the further development of departments of industrial medicine under University medical faculties situated in industrial areas and largely staffed by industrial medical officers and nurses to meet the need.

It is interesting to note that the Interim Report of the Social and Preventive Medicine Committee of the Royal College of Physicians (published October, 1943, and reviewed in *The Lancet* of October 30, 1943) recommends the establishment of Departments of Social and Preventive Medicine in every teaching school to organize a modernized course, covering the three clinical years, including social medicine in the strict sense and industrial medicine, and that the Royal College of Physicians take an active part in the organization of the teaching of this great subject to students, nurses, and medical social workers. It is desirable that industrial sister tutors be appointed and that an individual tutorial system be established to give the utmost flexibility in meeting the needs of individual students. This is the more necessary as basic professional experience during and subsequent to general training is variable and it often happens that an industrial nurse has had but little experience in those branches of nursing most valuable in industrial practice; one recruit may have acted as staff nurse or even Sister in an ophthalmic hospital and another have done very little eye work. Again successful adaptation to a new sphere depends upon many personal factors and helped by the reports which she will receive from the factories where the student does her practical work, as well as by her own observation and the students' expression of her difficulties, she is in a position to give valuable guidance. The professional and personal qualifications of tutorial staff are of supreme importance. They should have educational qualifications, sound and wide experience as practising industrial nurses, and those mellowed qualities of wisdom and human understanding essential to all who seek not only to teach but also to guide and inspire students on the threshold of their careers.



Personal Qualifications

Since by no means all are fitted for this specialty and bearing in mind the important consideration that it is to those specially trained to whom industry will naturally look to fill the senior posts in large organizations and in group medical and nursing services for small factories, and to take sole responsibility in the medium firm, pre-entry selection of students is essential. Attempts to base selection on psychological tests and technique fail in nursing as no tests have yet been devised to measure all-important traits of character and temperament. We must therefore fall back on the selection interview by experienced officers, together with records of general and professional education and, preferably, the added safeguard of at least 6 months experience in industry as junior sister in a large firm. The following standards are suggested as desirable:

Age of entry: preferably not under 25 years.

General education: matriculation or comparable standard preferably with science.

Professional qualifications and experience: S.R.N., S.C.M. Part I.

Special experience in casualty, ophthalmic, outpatient and dermatological nursing useful.

To have held supervisory posts as Staff Nurse or Sister, or to have had experience of public health nursing subsequent to training, is an asset.

Outside nursing experience in social work or a sound business training may be counted useful in equipping the industrial nurse.

In professional reports and references, technique, sympathetic understanding of patients, supervisory and organizing capacity are points to note.

Personal qualifications: A pleasant, dignified and acceptable personality. Interest in people. A sense of humour (if this can be assessed by a selection board). Adaptability. A bombastic or dominant personality is not likely to do well in industrial nursing.

Training within Industry

Finally we have now to turn to what might be described as 'training on the job,' training within the industrial organization itself, designed to give an introduction to the organization and its own special processes, hazards and methods and to stimulate interest by giving members of its nursing service as wide an experience as possible within its own limits, as well as to keep their nursing technique and procedures up to date by regular refresher courses. It is recognized that in the small firm this can only be done to a limited extent and mainly by encouraging nursing staff to avail themselves of such courses provided by outside bodies, such as the Royal College of Nursing and the Universities. But in the large combine and organizations which operate through a number of dispersal factories, much can be done internally. Training schemes now being launched in the Ministry of Supply Nursing Service may be of interest as an illustration.

Training Scheme within a Factory Nursing Service

(1) The issue to recuits to the service of an 'Initial Training Booklet' to serve as an introductory to factory organization and to its medical and nursing service. Subjects covered are:

(*a*) General factory organization and administration. Functions of the personnel department and liaison with the medical department. Safety and A.R.P. organization.

(*b*) Medical and nursing service, responsibility, scope of duties, routine nursing procedures, medical and surgical emergencies in the factory surgery, medical record-keeping, occupational hazards, preventive and prophylactic measures.

(*c*) Main provisions of the Health, Safety and Welfare Sections of the Factories Act. The Government Compensation Scheme. National Health Insurance.

(2) Issue monthly to nursing staffs of *The Ministry of Supply Nursing Service Bulletin*. Contains articles by industrial medical officers and sisters, labour managers, safety officers, works' chemists, etc., on industrial medicine and nursing, occupational hazards, accident prevention, etc. Also abstracts and digests on these subjects from medical, personnel and welfare journals, and the nursing press; book reviews, articles on social service and education. While much of general interest in these fields is included, the emphasis is on organization and hazards within our own factories.

(3) The establishment in three factories, representing each type of factory within the organization, of an initial training course of one week. Each recruit to the service will therefore have an initial training period of three weeks before taking up duty at the factory to which she is appointed.

(4) The establishment of three-day refresher courses held in a factory periodically and at least twice yearly for senior sisters.

(5) A period of training at a casualty and rehabilitation centre annually for senior sisters in order that they may keep up to date themselves and instruct their staffs in modern casualty technique.

(6) Subject to the exigencies of the service, attendance at week-end and one-day refresher courses organized by the Royal College of Nursing and Universities in London and the provinces is encouraged and travelling and subsistence allowances granted for such attendance.

APPENDIX

PRESENT TRAINING COURSES FOR INDUSTRIAL NURSES

A. The Royal College of Nursing Courses

(Note. The Royal College of Nursing was the pioneer in post-graduate training for industrial nurses in this country by inaugurating in 1934 a full-time course of one year's duration in conjunction with Bedford College for Women (University of London). Later part-time and six-months courses were also provided.)

A certificate is awarded to successful examination candidates on the completion of the courses. A minimum of 65 hours is devoted to lectures which are given by H.M. Medical Inspectors of Factories, industrial medical officers, industrial nurses, members of the Institute of Labour Management, staff of the Universities, and Public Health Departments, and other experts in the various aspects of the work.

During the course approximately half the time is spent in gaining practical experience in factories. In view of the wide divergence in conditions of work between one factory and another, even if engaged on similar work, every effort is made to ensure that students see not only different types of industry but also different forms of organization within industry. Throughout the course emphasis is laid on the preventive aspect of the work and the student is taught to regard health education as one of her duties. A study is made of the social and industrial background of the worker including a survey of the public health services. Group visits are arranged to illustrate the various subjects dealt with by the lecturers.

In the past these courses have been held only in London, but since 1943, through the generosity of the Nuffield Provincial Hospitals Trust, a grant has been made to the College, which has allowed of them being developed throughout the country. At present they are running in London, Glasgow, Leeds, Bristol; a course also began in Liverpool in January, 1944.

Note. Owing to the urgent demand for nurses during the war, only a three-months' course of training for the certificate is available, but nurses who have been employed in industry for at least two years, may enter for the examination on completion of the correspondence or part-time courses.

Syllabus of Three-Months Course

Health of the Industrial Worker 17 hours.

(*a*) Work of the medical section in industry. The scope of the medical department and its relationships with other organizations within and outside the factory. Examination of new entrants, prevention of epidemics, rehabilitation of injured persons. Treatment of minor ailments and the first care of medical and surgical emergencies. The organization of a first-aid service and the treatment of air-raid casualties. (*b*) Objects and methods of record keeping and guidance in the compilation of statistics. (*c*) Importance of vocational selection. Value of intelligence and dexterity tests. Effects of monotony, fatigue, boredom. The place of the defective in industry. (*d*) Factory legislation. The Factories Act, 1937, with special reference to factory hygiene, first-aid requirements, protected persons and work of the Examining Surgeon. War-time modifications of the Act. Workmen's Compensation Act. (*e*) Industrial diseases. The causes, occurrence and prevention.

Work of the Nurse in Industry 12 hours.

(*a*) The development of industrial nursing. The qualification and duties of an industrial nurse. Ethics. Planning, stocking and equipping the department. Nursing procedures in a work's surgery. Standing orders. Provision of ancillary services. Reports to management. Relationship to other departments. Study of environment and good working conditions. Co-operation with outside agencies. (*b*) The teaching function of the industrial nurse. Methods of conveying knowledge. Individual and group instruction. Methods of approach to different groups and ages. Preparation of notes and illustrative material. Demonstrations. Practical application. Preparation of talk. Presentation of talk to class and to training corps or club.

Work of Personnel Department 4 hours.

Works organization. Functions of Personnel Department and co-operation with Medical Department. Recruitment of labour. Apprentices, night school and continuation classes. Wages, upgrading and transfers within industry. Hours of work and absenteeism. Works rules. Committees, canteens and recreation. Problem of housing and transport.

Hygiene, Public Health Services and Communicable Diseases 13 hours.

(*a*) The importance of general hygiene with special reference to the problem and control of pediculosis and scabies. (*b*) Principles of diet, food values. Provision of canteens and problems of war-time catering. Balanced meals and the education of workers in choice of food. Modern methods of cooking. (*c*) Public Health Services. Types and work of local authorities. Maternity and Child Welfare schemes. The care of the child of the woman worker. War-time nurseries, nursery schools. Daily guardians. Adoption. Legitimacy Act. Affiliation orders. The housing problem. (*d*) The law relating to communicable diseases. The social aspects of these diseases with special reference to venereal diseases and tuberculosis. Mass radiography. Education of the public.

Social Services and Modern Industrial System 14 hours.

(*a*) Principles of relief and voluntary agencies. National Health Insurance. Pensions. Unemployment Insurance. Public assistance. Provision for the blind. Reconstruction and social security. (*b*) The structure of modern industry. Location, organization and control of industry. Large-scale production. Public and private monopolies. State control and private enterprise. War-time control of industry. Unemployment and trade cycles. Industrial relations. The history and functions of trade unions, trade boards, Whitley Councils. The function of Works' Councils and Joint Production Committees. Labour and wage legislation. Truck Acts.

Special Lectures 5 hours.

'Industrial eye casualties. Their nature, prevention and treatment,' with demonstration of nursing procedure. 'Work of the Probation Officer.' 'Accident prevention.' 'The work of the Hospital Almoner with special reference to Hospital Contributory Schemes.'

Visits of Observation to:

(*a*) Factories to see the medical departments, canteens, Air-Raid Precaution arrangements. Special hazards. Educational and recreational facilities. (*b*) Home Office Industrial Museum. Housing estate. War-time nursery. Health Centre.

Practical Work. 6 weeks.

Spent in factories, business houses, hospital skin and ophthalmic departments and in visiting with district nurses.

Over 100 firms throughout the country are co-operating in the provision of practical work and visits of observation.

Enquiries and applications should be addressed to The Director of Education, The Royal College of Nursing, Henrietta Place, Cavendish Square, London, W.1.

B. The University of Birmingham and Birmingham Accident Hospital Course

Certificate in Industrial Nursing

A course of training in Industrial Nursing is arranged jointly by the University of Birmingham and the Birmingham Accident Hospital for a limited number of State Registered Nurses. The course extends over one year, at the end of which time nurses who have satisfactorily completed the year's work and attended at least two-thirds of the lectures will be eligible to enter for the examination for the University's Certificate in Industrial Nursing. The examination is held at the end of each course of lectures, viz.: March, June and December, and will consist of a written paper of three hours and an oral. The fee for the examination is one pound. Nurses admitted to the course and not already in industry are required to reside in the hospital.

The Course in Industrial Nursing consists of: (1) At least fifty lectures dealing with medical and social aspects of factory life. (2) Visits and demonstrations at works. (3) Training in special hospital practice. (4) Four weeks in work within a factory.

Resident Nurses

The fee for the course for State Registered Nurses resident at the hospital is £15, which for their convenience may be deducted by equal monthly instalments from the salary paid to them by the hospital, which is according to the Rushcliffe Scale for staff-nurses. These nurses are entitled to 28 days leave during the year of training.

Non-resident Nurses

A limited number of State Registered Nurses who were actively engaged in industry before the 28th April, 1942, are allowed to attend the course of lectures when recommended by their managements. The fee in this case is £5 5*s*. for each of the three terms of the course. Such nurses, having satisfactorily attended the course of lectures, are eligible to sit the examination for the Certificate in Industrial Nursing.

Candidates may enter for this training at the beginning of January, April or October. For the convenience of nurses the lectures are held at the hospital and two lectures per week are normally given during the University terms.

Synopsis of the Course

Course I

Section A

The history of industrial medicine and the development of factory medical services. The place of the doctor and the nurse in industry. Ethics. The design and equipment of works medical departments and ambulance rooms in large and small factories, including their organization, administration, records, etc. Health education. Nutrition and dietetics. Personal hygiene. Infestation. Factory hygiene, the Factories Act and its health requirements in relation to preventive medicine. Sickness absenteeism in industry—physical and psychological causes and their prevention. Industrial fatigue. Industrial injuries, the teaching of first aid, casualty surgery of major and minor injuries, rehabilitation and workmens' compensation problems. Accident prevention. Eye injuries, their prevention and treatment. Occupational diseases—their prevention and treatment. The treatment of medical emergencies. Medical selection of entrants to industry. The management and adaptation of the medically unfit person in the factory. The health of the woman worker. The young person in industry. The nurse and Civil Defence duties.

Section B

Industrial Law and Relations. Industrial Administration and Social Services. What nurses need to know about the law—helping the injured workman—the law in war-time. Trade Unionism and its history—the Survey of Industrial Relations 1926—modern developments. Conditions of work in modern factories. Hours of labour, social environment and discipline, methods of wage-payment, wages and the standard of living, selection of workers. Effect of working conditions upon labour turnover, absenteeism, accidents, output and health, industrial fatigue and unrest. The study of industrial psychology. The control of working conditions: factory organization, welfare supervision and labour management. Safety measures. The keeping of statistical records. The development of our public social services. The present provision of both public and voluntary agencies. The social insurance scheme in respect of Health, Unemployment and Widows', Orphans' and Old Age Pensions. The work of the Assistance Board and of the Public Assistance Committee. The adequacy of the present provision and of the way in which further extensions may be looked for.

Course II

Visits to Works

This part of the course consists of practical lectures, demonstrations and visits to factories, at intervals throughout the year.

Course III

Hospital Practice

This includes training in the modern treatment of industrial injuries including first aid, and practical demonstrations of rehabilitation in all its phases, e.g. occupational therapy, recreational therapy, remedial exercises and physio-therapy. Nurses also have an opportunity of studying accident preventive measures at first hand, of obtaining some knowledge of liaison

methods between hospitals and industry, the sociological problems of accidents, and the economics of absenteeism. Special training is also arranged at the Birmingham Eye Hospital and the Skin Hospital.

Course IV

Work in the Factory

This takes the form of four weeks' resident experience under the direct supervision of industrial medical officers and senior industrial nurses at one or more of the firms included in Course II.

Enquiries, communications and applications should be made to the Matron of the Hospital, from whom further particulars may be obtained.

Miss M. Bonthron, Matron, Birmingham Accident Hospital.

George Grant, Registrar, University of Birmingham.

C. The University of London

Diploma in Nursing

Under Part B candidates may offer 'Industrial Nursing' subject to the following Regulations :

(*a*) That her name has for not less than two years been on the General Part of the Register of Nurses, or that she has for not less than two years been eligible to sit for the examination admitting to that part of the Register; and (*b*) *either* that she holds a Certificate in Industrial Nursing of the Royal College of Nursing awarded after one year's course of study, and has had since completion of training one year's practical experience in a nursing capacity in a factory or business house which employs the services of a whole-time medical officer; *or* that she has had since completion of training three years' practical experience in a nursing capacity in such a factory or business house.

Industrial Nursing Syllabus. (Two papers, each of three hours, and an Oral Examination.)

(i) *Industrial and Social Conditions in Modern England. Industrial Conditions*

Large-scale production and the modern organization of industry. The location of industry. Industry and the State: Public Utility; Industrial regulations; Factories, Mines and Shops Acts. Industry and the Worker: Wages, Trade Boards and Whitley Councils; Truck Acts; Accidents and Compensation; Unemployment; Employers' Liability and Workmen's Compensation. Trade Unions and their problems.

Social Conditions

Social conditions and the administration of those public social services directly related to the welfare of the individual. Voluntary agencies and their relation to statutory bodies—constructive relief; indiscriminate relief. Public provision made for the protection of women and children; child adoption; boarding-out of children. Maternity and Child Welfare. Importance of pre-school age. Education, educational opportunities in relation to the varying age, mental and physical capacity of the scholar—promotion of physical fitness and recreational activities. Social Insurance—National Health, Contributory pensions (compulsory and voluntary)—Unemployment.

Housing. House property management. Difficulties affecting family life from urban overcrowding, and those which arise on new housing estates. Community Centres.

Mental Health. Care and protection of defectives under the Mental Deficiency Acts. The work of voluntary Mental Welfare Associations and the care of borderline cases—social problems arising from mental retardation and mental instability; preventive and remedial measures—Child Guidance Clinics, the Mental Treatment Act.

Juvenile Delinquency; main provisions of the Children and Young Persons Act. Personal, family and environmental factors associated with delinquency and with anti-social conduct and expenditure. Prevention of crime. The social value of the right use of leisure. Moral welfare work.

Special services, state and voluntary, for the blind, cripples; the infirm and aged, the sick—social assistance services, non-contributory Old Age Pension; Unemployment Assistance and Public Assistance under the Poor Law. Provision, public and voluntary, for the homeless.

(ii) *Health of the Industrial Worker*

Factors involved in maintaining normal health. Physical and mental aspects. Preventive side of the nurse's work. Examination and care of young persons. The psychological effect of home and other environment and of employment on the health and development of adolescents. The scope of medical industrial psychology including the methods of study and research available for particular problems, with special reference to personnel management and vocational guidance. The place in industry of the mentally and physically abnormal.

Rest Pauses. Hours of work. Safety principles and appliances. Agencies dealing with national health and safety. Processes and principles of observation. Procedure in visiting departments. Varieties of factory work. Instruction in the principles of accurate recording and of reading instruments of precision, including recording of blood pressure Hygiene of outdoor life, including camps, holidays and games.

The causes, occurrences and prevention of illnesses and diseases. Treatment of minor ailments and the first care of medical and surgical emergencies. Heat stroke. Fracture clinics. The control of infection including tuberculosis and venereal diseases and their social significance. Social and medical services available for the worker.

(iii) *Work of the Nurse in Industry*

The history and present position of industrial nursing. Medical, hospital, district and visiting nursing services available. Educational duties with regard to group and individual instruction. Various methods employed. The equipment of the first-aid room. The buying of stores and dressings. Methods of keeping, filing and compiling systematic records and reports. Sickness rates and their interpretation. Charts and graphic methods of illustrating facts.

The industrial background. Factory organization, etiquette and relationship between welfare and other departments, co-operation with outside agencies. The work of an employment department. Industrial welfare, general working conditions and group insurance. Canteen and recreational activities.

The principal legal enactments, regulations and orders connected with the above-mentioned subjects.

Enquiries and Applications (temporary war-time address) should be addressed to: The Registrar, University of London, Imperial Institute Road, London, S.W.7.

DESIGN OF DRESSING STATIONS

AND CONTROL OF WOUND INFECTION

BY

WILLIAM GISSANE, A. A. MILES and R. E. O. WILLIAMS

From the Clinical Staff and Medical Research Council Unit, Birmingham Accident Hospital

Introduction

In spite of the recent advances in the treatment of wounds by antiseptic and chemotherapeutic agents, the aseptic treatment of wounds still remains the most effective way of controlling the infection that may occur during treatment. Aseptic technique is seen in greatest elaboration in the operating theatre, but theatre technique is obviously impracticable in wards, out-patient departments and factory surgeries, where asepsis is nevertheless of equal importance. Simple and practicable precautions can be devised for these places. However, recent surveys in wards and out-patient departments have revealed a high incidence of wound infection due to defects in the aseptic dressing of the wounds (see M.R.C. War Memo. No. 6). The defects are not altogether due to the difficulties of surgical practice or the greater frequency of dirty and damaged wound tissue in war-time; defective aseptic techniques can also be found in civilian practice where peace-time conditions prevail.

The appearance of gross and sometimes fatal sepsis can be traced in many instances to infection of the wound during its treatment. In industry these cases are referred to hospital, with the result that sepsis of industrial wounds looms large in hospital practice, but does not strike the factory staff as anything more than a rare occurrence. Many wounds are already septic when first seen in the factory surgery, but a proportion of open wounds become septic during treatment. It has been argued that this latter sepsis is not due to any gross breaches in aseptic precautions, but to accidents whose prevention could be achieved only by impracticable elaboration of the routine of treatment. The argument is, we think, invalid, because the incidence of sepsis can be reduced by simple revision of dressing technique. But even if it were valid, there would still be a strong case for a careful review of existing methods, for obvious sepsis is not the only result of cross-infection of wounds. Our recent bacteriological survey of wounds in factory surgeries and out-patient departments (unpublished) has shown that from 30 to 40 per cent. of all clinically clean wounds more than one day old are 'silently' infected, usually with *Staph. aureus* and sometimes with *Str. pyogenes*. The results of sepsis are well recognized: quite apart from frequent permanent disabilities, the sepsis is responsible for prolonged attendance at hospital and prolonged absence from work. Similarly, but to a lesser degree, silent infection prolongs the period of treatment of the wound. For example, the mean duration of hospital treatment of 188 minor sutured wounds of the hand, classified into clean, silently infected, and clinically septic, was as follows:

Clinically and bacteriologically clean (80 cases)	15·6 days
Clinically clean, with 'silent' infection (58 cases)	18·2 days
Clinically septic (50 cases)	25·4 days

Taking these small wounds as an example, it is obvious that the time, both patient's and hospital's, that would be saved by eliminating silent infection of a wound is not great (about 18 per cent.). But the saving, even in patients with such wounds, becomes highly significant when we consider the incidence of silent infection and the total number of wounds which may be silently infected. The silent infection rate may be as high as 40 per cent. and, as an example of the number of wounded persons treated, we may quote figures from a group of large factories employing 103,000 workers, where, in 1942, no less than 430,310 first dressings and 615,333 redressings were performed. (Dr. Donald Stewart, personal communication.)

Silent infections occur in all kinds of wounds and may have other consequences beside that of delayed healing. For example, in our view it is not unreasonable to attribute to it a common feature of many wounds said to have healed by first intention. These wounds, after a period of healing unaccompanied by sepsis, develop a scar which remains red and swollen, and which may for months be so tender as to constitute a prolonged disability. It is highly probable that this scar represents a reaction to silent infection; the point is under investigation.

There is another important aspect of silently infected wounds. They are particularly dangerous in a dressing station, whether of factory surgery or out-patient department, because they are unrecog-

nized sources of large numbers of pathogenic bacteria. By definition, they cannot be recognized clinically, and are consequently treated as clean wounds. It is a matter of frequent observation that medical and nursing staff will treat a series of apparently clean wounds with no more than the most perfunctory aseptic and antiseptic precautions for each patient, and with none whatsoever to prevent the spread of hypothetical infected material from one patient to the next.

The rapid succession of patients with silently infected wounds in a busy dressing station means that a large reservoir of infection is constantly present. A good dressing technique must therefore minimize the incidence of clinical sepsis, which may be small, and of the silent infection, which constitutes, numerically at least, a bigger problem.

Unfortunately, the reduction of silent infection can be demonstrated only by a bacteriological study over a long period. But wherever we have made these studies we have found a high incidence of added silent infection, a fact which suggests that aseptic routines as generally practised could be greatly improved in this respect.

The possible sources from which a wound may become infected with *Staphylococcus aureus* and *Streptococcus pyogenes* are: the nose, throat and skin of the patient himself or of the nurses and doctors who attend to his wound, and, in the factory surgery and hospital particularly, infected wounds of other patients. The occurrence of wound to wound infection has been attested by several recent reports (Miles *et al.*, 1940; Spooner, 1941; McKissock, *et al.* 1941) and McKissock *et al.* were able to show that it could be controlled by the introduction of a dressing technique designed to minimize the transference of pathogenic organisms from one wound to another. We have been able to confirm these observations (Williams, Clayton-Cooper, Howat and Miles, unpublished).

We recognize that the maintenance of a completely sterile wound is an unattainable ideal. Infection depends both on the susceptibility of the tissues and the dosage of pathogenic bacteria introduced into them. The treatment of the wound helps to reduce its susceptibility to infection. Aseptic measures, by eliminating several of the more important sources of infection, reduce the infecting bacteria to numbers that the tissues can overcome.

Routine of Wound Dressing

The best general method of reducing added infection is by revision of the dressing technique. We use the word ' revision ' rather than ' improvement ' or ' elaboration ' because, from observation of a large number of dressing stations, it is clear that though some preventive measures are inadequate, others (e.g. ' scrubbing-up ' instead of the use of dry hands and a ' no-touch ' technique) are unnecessarily elaborate. In many cases, the routine can with advantage be ' rationalized ' and the time thereby saved is more than enough for taking additional aseptic precautions.

For the most part dressings are, from a bacteriological point of view, either carelessly or very badly done. A careful scrutiny of any routine will yield a list of preventable breaches in the anti-bacterial protection that it is supposed to afford. But to offer a list of remedies to a busy medical staff is, on the face of it, to offer an additional burden of work. The minutiae of the aseptic routine and the therapeutic manipulations are already reduced to a practicable minimum. The staff is not prepared to spend time on improvements whose value only a long-term application will reveal.

The problem, therefore, is to introduce a dressing routine which respects silent infection as well as obvious sepsis without increasing the time spent on each patient, and its solution lies in the analysis of existing routines from the standpoint of functional efficiency. Most dressing stations are no more than rooms furnished with a number of medical appliances—trolley, sink and perhaps sterilizer—placed without much regard to their function. If the wash-basin is 12 feet from the patient and dressing trolley, the wash-basin tends to drop out of use. If the sterilizer is relatively inaccessible, either the sterilization is omitted or it is done badly on the trolley with far too dilute antiseptic.

The main routes of added infection are: (*a*) the hands and pocket scissors of the dressers; (*b*) the trolley instruments; and (*c*) ' clean ' dressings, lotions and their containers, all of which may have been contaminated in bulk when portions are removed by contaminated hands and instruments while a dressing is in progress. Carriage of infection on the hands can be prevented by washing after each dressing, and contamination on scissors by keeping them in antiseptic.

Contamination of clean dressings in bulk can be avoided in many ways. *The single-handed dresser* may use packets containing enough material for one wound, though this method is time-consuming for large numbers of small wounds. Alternatively, before each dressing the requisite amount of material can be gathered in a sterile bowl with sterile instruments from the clean store. This we term the ' cafeteria ' method. The required aseptic conditions can also be achieved by the provision of containers for bulk dressing material that allow withdrawal under sterile conditions without lid-lifting, etc.—' safe-sampling ' containers. The design of such a container is under consideration.

Two nurses may act as dresser and server. The server hands to the dresser everything required from clean stocks, and never comes into contact with infected material. She also looks after the trolley supplies for each dressing and supervises the sterilization of instruments, etc. One server can supply two or perhaps three dressers in a dressing station working to full capacity.

We will consider first the single-handed dresser, and later the modifications required for dressing teams of two or more. The ideal dressing routine

for an open wound is briefly: setting of the dressing trolley; removal and safe discard of soiled dressings; inspection and toilet of the wound; dressing of the wound with clean material; cleaning and sterilization of instruments, bowls, etc., used in the dressing; washing of the hands; and, finally, recording the treatment of the patient. In practice, the routine is often: unbandaging and inspection of the wound; selection of material; toilet and dressing of the wound; recording of treatment; clearing up of soiled and unused dressings; and, finally, proceeding to the next patient.

The requirements for the ideal procedure are briefly as follows:

1. Trolley, with sterile or 'clean' (where 'clean' means 'free from pathogenic bacteria') dressing materials, preferably in safe sampling containers from which portions can be taken without contaminating the whole store.
2. A near-by deep and capacious discard bin.
3. Sink for washing instruments.
4. Sterilizer.
5. Wash-basin (may be the same as No. 3).
6. Records desk.
7. Cupboard or shelves for spare dressing stores, etc.

In factory surgeries a good deal of dirty material on wounds might be removed by the patient himself, and a separate patients' wash-basin and discard bin, to facilitate preliminary cleansing of the parts surrounding the wound, might be added to the list.

Lay-out of the Dressing Station

The awkwardness of the design of existing dressing stations, for the purposes we have outlined, is exemplified in Plans I–VI, which are based on some of the surgeries we have visited. They are self-explanatory. The seven essential pieces of furniture are indicated, where they exist, by the numbers given in the above list of requirements. The order is that in which the different pieces of equipment would be used during a wound dressing properly carried out in the way outlined above. The bin, No. 2, will not be found in most of the diagrams; soiled dressings were usually discarded into a shallow bowl kept on the lower shelf of the trolley, of such capacity that it was filled to overflowing after half an hour's continuous work. In the plans the path followed by the nurse is shown by the continuous line with arrows, that followed by the patient by the broken line.

Surgery I is shown twice. In Ia the path taken by the dresser during her routine is plotted; in Ib, the path she would have taken if following the 'ideal' routine. In II, III, IV, V and VI the paths are those necessary for carrying out the 'ideal' technique. The path in most instances includes a visit to the store cupboard. In practice, the paths usually lay between the dressing trolley and the records desk (1 and 6), and a glance at the plans of these surgeries shows that even for the practice of an inadequate dressing technique, the lay-out is not efficient. In the treatment of 40 patients in one morning, a nurse might walk at least an unnecessary half mile.

Plan VII represents a hypothetical small surgery (12 feet by 12 feet) where this movement is reduced to a minimum. The principles of its layout are:

1. The essential pieces of furniture are gathered around the dresser, in the best light, and away from the door. They are placed so that the dresser, when standing ready to deal with a patient, has to take a maximum of one or two paces to reach the trolley, the records desk or the wash-basin and sterilizer respectively.

2. Where movement about the surgery is essential the patient, rather than the dresser, does the walking. But the plan is so arranged that at no point does the track taken by the patient from door to waiting bench, to his wash-basin, to the dressing chair and out of the room again, cross that taken by the nurse in carrying out her duties as a dresser.

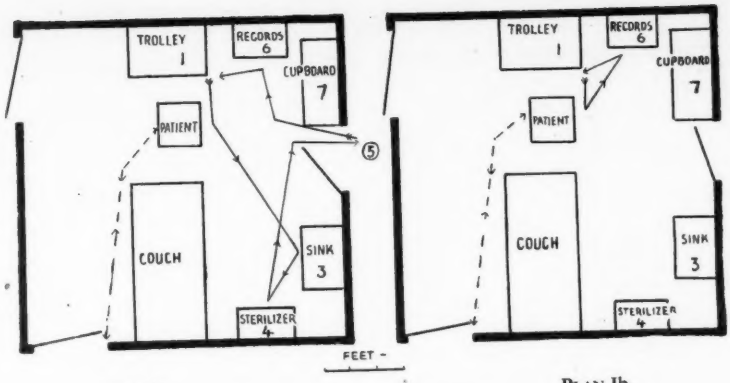
A second wash-basin is provided for patients. A third is placed near the couch, so that if dressings are to be done on a recumbent patient, a bacteriologically safe unit is constituted by moving the trolley over to the couch side. The line around the couch indicates the position of an overhead trolley rail from which depends a curtain that can be drawn at will around the couch.

Plans VIII and IX show respectively an out-patient dressing station and a ward side-room at the Birmingham Accident Hospital, which were devised by the application of the principles outlined above. Plan VIII was designed to accommodate a doctor and his secretary, four nurses (two acting as dressers and two as servers) and two patients at one time. Each member of the staff has ready access to his work and to a wash-basin. The servers work outside the low walls WW (5 feet high), passing clean material through one hatch, and taking soiled instruments, etc., through another. The dressers work from a fixed dressing bench. Dressings are discarded into a bin in an enclosed cupboard under dressing slab. The bin is removed for emptying through a door outside the dressing station. The doctor sees each patient with no more movement than the turning of a swivel chair. Should he handle a wound, the wash-basin is immediately behind him for his use. The paths taken by the dressers and by the patients are plotted in the plan.

Plan IX is of a side-room of a ward used mainly for patients with septic wounds of the hand, adapted to the needs of a four-nurse team dressing technique. The team consists of two dressers, a server and a runner. The dressers share one trolley. Here the function of the dressers is simpler than in a factory, since there are no records to be written during the dressings. This arrangement has been in use for 14 months, and, once the nurses had learnt their respective duties in the team, proved to be generally as well as bacteriologically efficient.

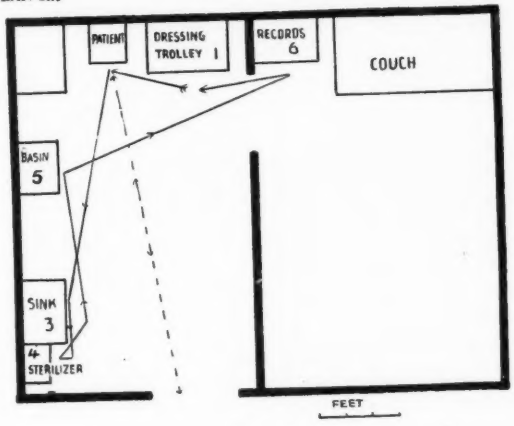
Factors Determining Design

The factors that must be considered in designing a dressing station comprise those which are common

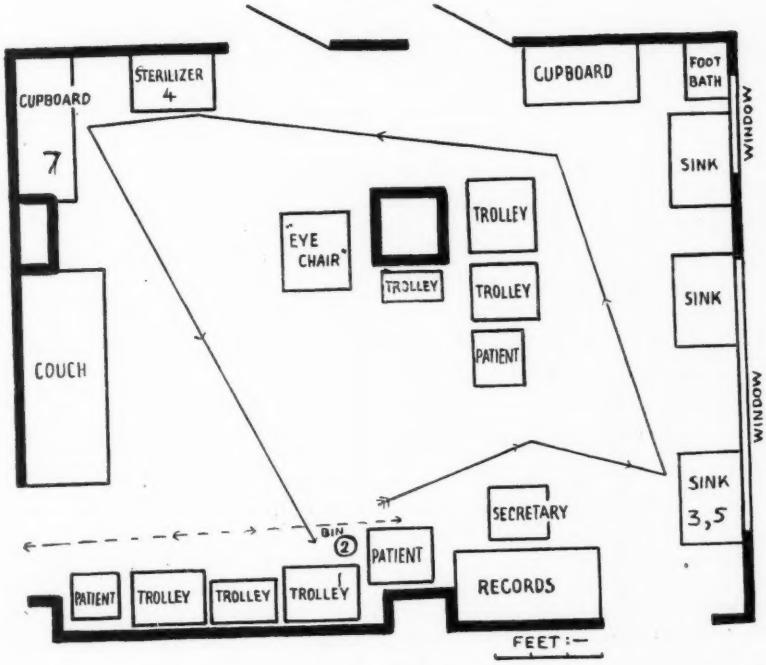


PLAN Ia.

PLAN Ib.



PLAN II.



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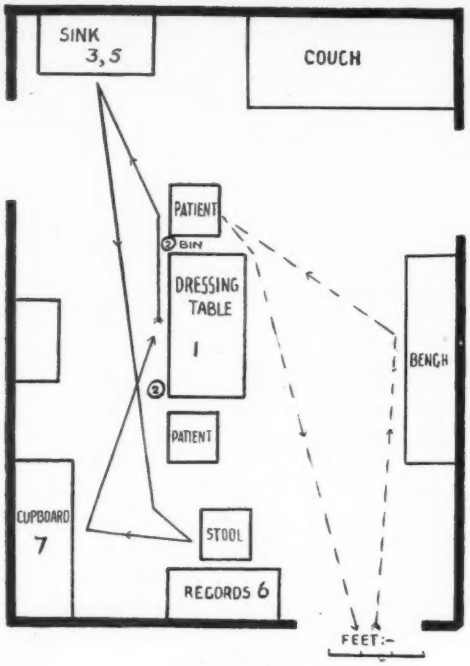

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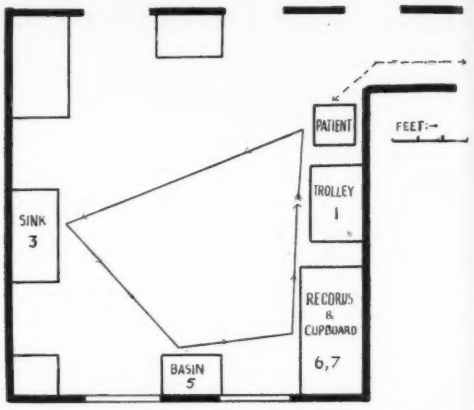
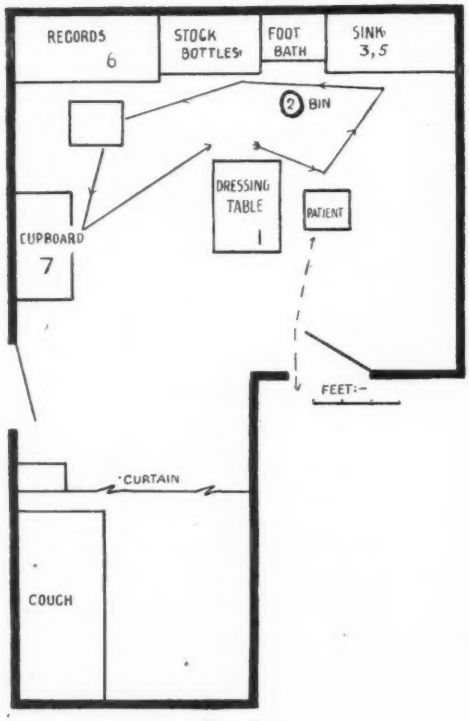


PLANS I–VI.—Sketch Plans of Factory Surgeries. Broken line shows path followed by patient. Continuous line shows path of nurse doing one dressing with the 'ideal' routine described in the text (except in Ia, where it shows the path that she actually followed). Surgeries shown in I, II, V and VI were staffed by one nurse only; III and IV by two to three nurses. Lighting was artificial in II, IV and VI; I had a skylight; III and V had windows. For key to numbers, see text.



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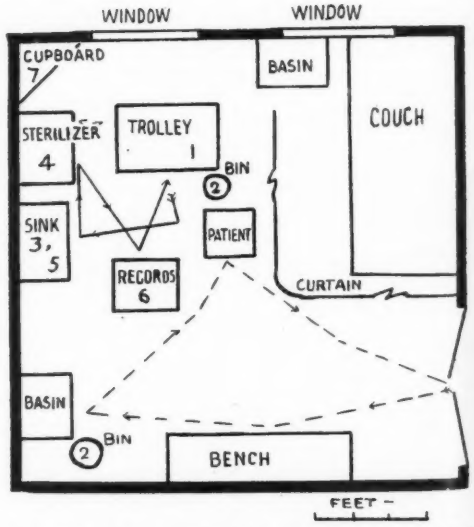
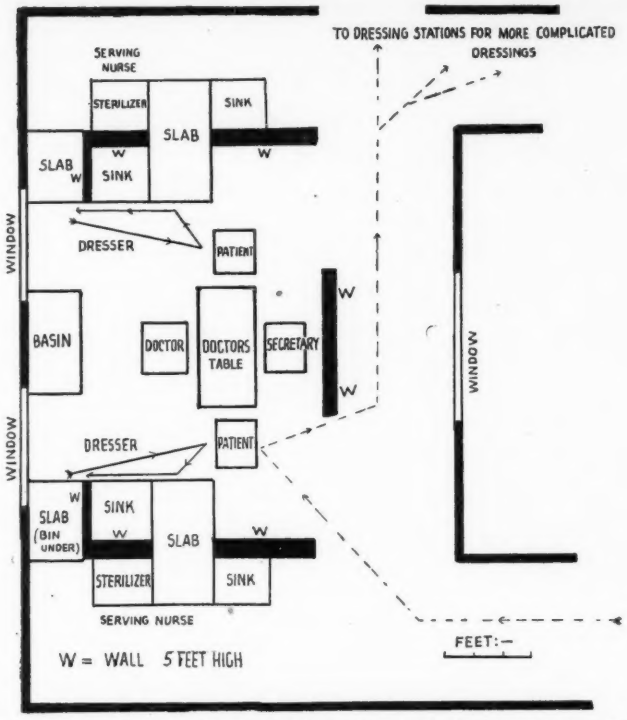


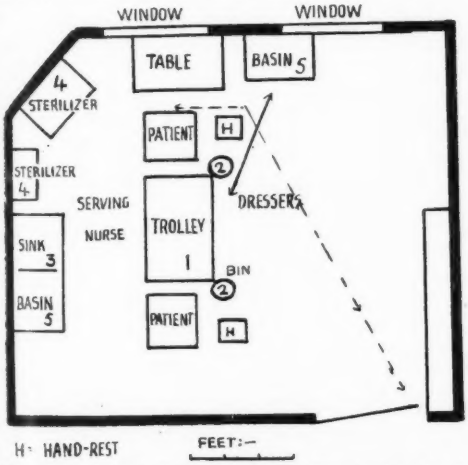
PLAN VII.—Plan of suggested lay-out for surgery, staffed by one nurse, based on principles discussed in text.



PLAN VIII.—Part of the New Out-Patient Department, Birmingham Accident Hospital.

to works surgeries and to hospital departments, and those which are, for the most part, peculiar to works. The list that follows is not intended to be comprehensive in respect of works factors; we do not as yet know enough about them.

1. *Geographical.*—The dressing station must be readily accessible. The number of injuries per person per month reported in a works surgery that was not more than 50 yards from the remotest worker, was 4·5 times the number in a comparable room (in a factory doing similar work, under the supervision of the same medical officer) where some of the workers had to walk 10 minutes to get to it. (Dr. E. H. Capel, personal communication.) Stairs, and a walk in the open air, are also said to discourage attendance.



PLAN IX.—Ward Dressing Station, Birmingham Accident Hospital, for two dressers working simultaneously.

2. *Structural.*—The rooms should be spacious enough for the staff and work intended. Day lighting is preferable, but good artificial lighting, especially fluorescent tubular lighting, is satisfactory for minor surgical manipulations.

The position of the doors and windows in the room is usually fixed. The dressing area, where the essential furniture (1–6 in the list above) will be disposed, should be as remote as possible from the door, and placed so that the path taken by the ingoing and outgoing patients does not cross the path taken by the nurses. In larger dressing stations, designed for more than one dresser with servers, the design must ensure that the paths of the servers and dressers do not intersect more than is necessary. If the dressing area can be placed under a window, so much the better; but day-lighting should be sacrificed to drainage. The sacrifice is often necessary, for water points and drains, being expensive to alter or extend, often define the position of the sinks and wash-basins,

and it is part of our thesis that awkwardly placed basins frequently determine that omission of hand washing and instrument cleansing which constitutes the largest gap in the defence against surgical infection. In general, the wash-basin and sink should be close together, and in the middle of the wall along which the supply of drainage and water points is most convenient. From that fixed point the remainder of the dressing area may be planned. The table with the sterilizer adjoins the sink against the wall. A shallow stock cupboard hangs at face level above the basin and sink. The dresser will work with her back to the hand-basin and sink, with the dressing trolley, discard bin and records desk conveniently disposed at one side or the other. The patient's chair is immediately in front of the dresser. The records desk should be at standing height (a foot rest for leg injuries is conveniently stored under it). The records desk accommodates the day sheet, special sheets, certificates, etc. In larger surgeries there may be a single records desk or office, in charge of a clerk, and here it is more convenient to give each patient a small card upon which all his notes are written. In such a case only a small records desk is needed, or a small hinged flap may be added to the dressing trolley to accommodate the individual cards.

The trolley should be on wheels, so that it can be moved, if necessary, to a couch in the cubicle. The curtained cubicle, if it is far from the hand-basin, should be provided with a separate hand-basin. If possible, the curtains should run on suspended trolley rails, so that the floor is not encumbered with upright rail supports.

3. *Social Considerations.*—In many factories, especially those that in peace-time employed women, there is a strong tradition of segregation of the sexes in a surgery. In others, the practice is similar to that of hospital out-patient departments, where there is no segregation. The manipulations that require exposure of the covered parts are carried out in a cubicle. The cubicle method, however, is often inconvenient, for either the whole paraphernalia of trolley, etc., must be taken over to the cubicle, or the dressing done by an imperfect technique. It seems to us that the principle of a dependent curtain rail, suspended at a height of 6 feet 6 inches along the periphery of the dressing area nearest to the waiting patients, round which an easily running curtain might be drawn to seclude the seated patient deserves trial as a convenient and time-saving device. It has the advantage that in small surgeries, the cubicle, which usually contains the couch, is left free for patients suffering from faints, shock and other medical conditions needing relatively long treatment.

The provision of a basin at which the work-soiled patient can give himself a preliminary wash worked well in one factory surgery we inspected, but its use must be carefully supervised and individual towels must be provided; otherwise it might become a potent source of cross-infection of wounds.

4. *Technical Considerations.*—In the small surgery, where simplicity of procedure is essential to a rapid turnover of patients without too great a lag at the rush hours, several technical improvements on the usual procedure are possible. Among these we may note:

(*a*) The provision of readily sterilizable lidded bowls in which dry, sterile instruments and dressings may be stored.

(*b*) The provision of safe-sampling containers for sterile dressings, gauze, lint and wool.

(*c*) The provision of vessels delivering required quantities of sterile fluids, i.e. 'safe-sampling' fluid containers.

Both (*b*) and (*c*) are required for the cafeteria technique.

(*d*) Reduction of the multiplicity of cleansing lotions, antiseptics and therapeutic substances, applied to the wound. The average dressing trolley would be large enough for the proper practice of aseptic rituals, if it were not crowded with bottles and ointments. Most trolleys resemble a well-stocked cocktail bar.

(*e*) The provision of easily applied, flexible, occlusive dressings that do not require renewal. A man at work with a hand wound, which requires elaborate dressing, may return to the surgery every two hours for rebandaging, especially if he is working with fluids.

In collaboration with the hospital staff, industrial medical officers and nurses, we have attempted some of these technical improvements, but more investigation is required to define the most satisfactory materials for the initial cleansing of the wound, for use as an antibacterial dressing, and for the immobilization and cover of the wound.

As an example of the application of the principles enunciated above we may describe in some detail the reorganization of a temporary dressing station at the Birmingham Accident Hospital used for out-patients with established sepsis of wounds (Plans X and XI). Between 9 a.m. and 1 p.m. some 60–80 patients are seen and treated in the dressing station. In all cases the wound has to be inspected by a doctor; treatment may be simply a dressing, or may involve a preliminary soaking in a bath.

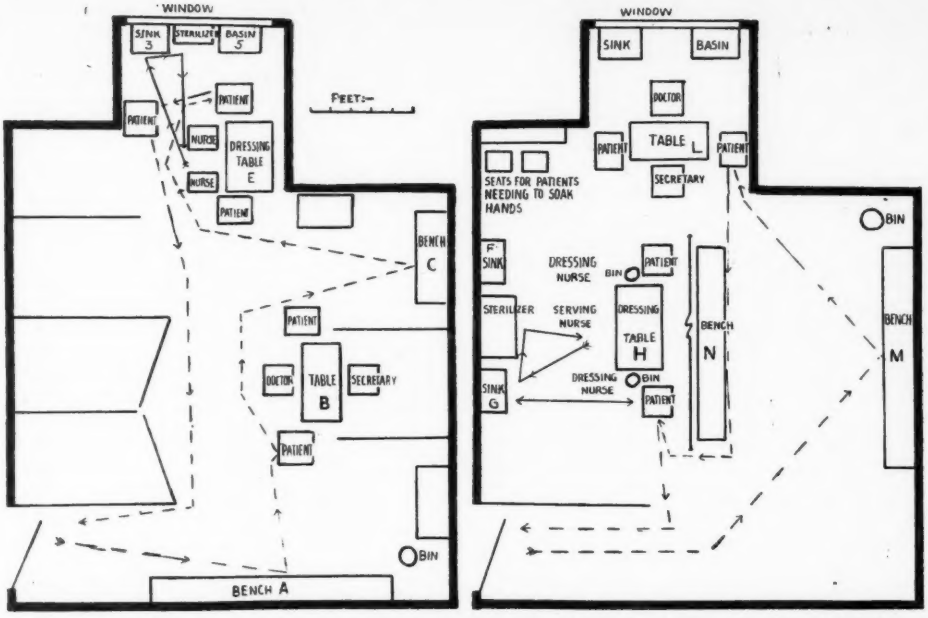
Plan X shows the original lay-out of the station. The general arrangements were as follows:

1. Patients entered by the door and sat on the bench (A) where they removed their dressings and put them in a large bin.

2. Patients were seen by the doctor (B) at a table near the middle of the room, and remote from a wash-basin and the light.

3. Having seen the doctor and had a temporary dressing, in the form of a piece of gauze, put on their wounds, the patients waited for their dressings on the other bench (C).

4. Dressings were done by two nurses working at a table near the window and wash-basin (E). They used the 'cafeteria' method. As will be seen from the plan, there was great congestion at this end of the room, in part because there were so many



PLANS X and XI.—Part of a temporary Out-Patient Department, Birmingham Accident Hospital, before and after reorganization. For key to letters, see text.

people congregated in a small area, and in part because the route taken by the patients crossed that followed by the nurses in taking instruments to the basin and sterilizer. The congestion was accentuated by the practice of having a runner to help with the bandaging, so that when the wound toilet was finished the patient had to move to another seat for bandaging.

The disadvantages of the plan may be summarized as, firstly, that the doctor saw the patients in a situation where the light was bad and whence, to get to a wash-basin, he had to go right through the collection of nurses and patients at the dressing table; and secondly, that the dressings were done, though near a wash-basin, in an area which made congestion inevitable. The result was that the nurses were unable to keep pace with the flow of patients, and a queue formed in the middle of the room.

The principles set out for the model factory surgery had to be modified somewhat in this case, since all patients were to be seen by a doctor before the wounds were dressed by the nurses. Nevertheless, the requirements were similar: all who have to handle wounds must be near a wash-basin; the dressings must be done near to the sterilizer; the paths followed by the patients and nurses must not cross; and inspection and treatment of wounds should be done in a good light.

The alterations made in the dressing station are shown in Plan XI. New wash-basins were inserted at (F) and (G) and the sterilizer was transferred to a table between them. This was then made the focal point for the dressers, a table being arranged at (H), so that the nurses had access to basins and sterilizer, while the patients could easily reach their chairs. The team method of dressing, with a server, was introduced. The doctor's desk was transferred to the position (L) where he was under the window and near a wash-basin. Patients waiting to see him had plenty of space at (M), while those who had seen him and were waiting for dressings, could sit along the bench (N). A comparison of the routes followed by patients and staff on the Plans X and XI demonstrates the simplification achieved on paper, and this had been borne out in practice; the nurses are able to follow the safer dressing technique while taking less time over each patient.

Summary and Conclusions

Added infections during the treatment of wounds in a factory surgery produce manifest sepsis in a few cases and silent (clinically inapparent) infections in a much larger number of cases. Silent infection, which may be present in up to 40 per cent. of the wounds treated, not only delays healing but also creates a large reservoir of organisms capable of infecting clean wounds treated in the same surgery. Aseptic technique must therefore be designed to prevent cross-infection of wounds from those already septic or silently infected. Relative freedom from manifest sepsis is not a safe indication that the aseptic routine in use is fully efficient.

Aseptic techniques are often defective because the plan of the dressing station makes the practice of a completely safe routine unduly laborious. A revision of the technique usually implies a redesign of the dressing station.

We have discussed the requirements of a dressing station which would allow the easy performance of a safe routine. The plan should be such that the dresser works conveniently close to the patient, the wash-basin and sterilizer, and the records desk, and that all unnecessary movements of the dresser are eliminated. Reorganization of a hospital dressing station along these lines enabled the staff to carry out a revised and safer dressing technique, with a decrease in the average time spent on each dressing.

Our detailed recommendations are, for the most part, trite, but we have so frequently observed the inconveniences which they are intended to remove that we have no hesitation in making them explicitly. We have also borne in mind that the factory surgery is used for other purposes beside wound dressing. The application of the principles of dressing station design need not interfere with other functions of the factory surgery.

It should perhaps be emphasized that we consider the proper design of dressing stations to be a preliminary step in the control of wound infection. Only when added infection is minimized can the optimum methods of treatment of both clean and infected wounds be assessed with any confidence.

Acknowledgements

We are greatly indebted to the medical officers and nursing staffs of a large number of factory surgeries for co-operation in our survey and for much practical advice; and to our colleagues at the Birmingham Accident Hospital for their help.

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FIRST-AID TREATMENT OF BURNS AND SCALDS

BY

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In writing about the management of burns it is important to distinguish clearly between :

(*a*) Treatment applied as a purely temporary measure at the scene of the accident, before the patient is despatched to a hospital or doctor. This is strictly first aid.

(*b*) The formal treatment, carried out by a doctor or nurse, whether in the home, the surgery or the hospital, who has adequate facilities at his command. This we have termed, at the suggestion of Sir Almroth Wright, *the plenary treatment*, to convey the idea of completeness.

(*c*) Subsequent dressings, skin grafting procedures, etc.

The present paper is concerned only with first aid—and almost entirely with the local treatment of the burn. Civilian burns have been chiefly in mind, but the principles underlying treatment are the same for burns sustained on active service.

There is no agreed policy with regard to the initial treatment of burns. Owing to the urge to do something, however ill-advised, 75 per cent. of civilian patients arrive at hospital with some kind of application to the burned area—olive oil, flour, coagulant jellies, cold tea, sodium bicarbonate, an 'ointment,' or flavine, etc.—often covered with a dirty, or at least a non-sterile, piece of cloth.

Frequently pain has not been relieved by these applications—sometimes it has been increased ; and the difficulty of removal of the semi-coagulated jelly, the oil or the caked flour, may well aggravate the original trauma suffered by the burned tissues, thereby favouring the development of shock.

First-aid remedies of this kind, especially if applied, as they usually are, without aseptic precautions, may well do much more harm than good.

In view of the great importance of burns in the mechanized warfare of to-day, and their contribution to wastage in industry, we have attempted to formulate a simple first-aid procedure which would be generally applicable, and have a satisfactory *raison d'être*.

Such an ideal first-aid procedure should :

(*a*) Relieve pain promptly and, by so doing, cut off sensory stimuli which probably play some part in inducing shock.

(*b*) Prevent the arrival of pathogenic organisms —in particular of haemolytic streptococcus—on the burned surface ; or, if this has already happened, destroy it or prevent its multiplication.

(*c*) Do no further damage to the already injured but viable skin tissues, nor interfere with the natural anti-bacterial defence by leucocytes.

(*d*) Be easily removed by gentle washing with a watery solution during the subsequent clean-up in hospital or the surgery.

(a) Relief of Pain

This was studied in two ways :

(1) By direct observation on small experimental burns on the human subject.

(2) By the application of creams containing analgesic agents to a series of accidental burns in factories and in the Burns Ward of the Royal Infirmary, Glasgow.

The experimental human burns were caused by a flat-bottomed copper tube through which water at temperatures of 55° to 60° C. was circulating (Leach, Peters and Rossiter, 1943). Light pressure with this tube on the forearm for 45–50 seconds gave a fairly uniform, manageable, second-degree burn, which was more painful than burns caused by higher temperatures for a shorter period.

Observations on some twenty-four of these standard low-temperature burns showed :

(i) That exposure to air caused pain and hot air increased it. The burned area is partially anaesthetic (prick test).

(ii) That cold water or any cold watery cream gave instantaneous relief (cooling effect), but this was usually short-lived and was followed by a variable amount of burning or throbbing which lasted for an hour or more.

(iii) The application of local analgesics in a cream composed of—

Cetyl trimethyl ammonium bromide ('Cetavlon') ..	1	per cent.
Cetyl alcohol	5	,,
Linseed oil	25	,,
Water to	100	,,

sometimes afforded more relief than the cream alone but the effect was not constant

in different individuals. The local analgesics tested were :

Orthocaine B.P. (' Orthoform ')	2	per cent.
Benzocaine	0·5	,,
Percaine	1	,,

The effect of these analgesic creams on accidental burns was similarly difficult to assess. At Messrs. Rolls-Royce, Ltd., the medical officer and his surgery staff were definitely of the opinion that the cream containing orthocaine was superior to those with other analgesics, and to the same cream without any analgesic. He also reported that very satisfactory healing, with almost no sepsis, resulted when this cream was left on the burns as the sole treatment. At another factory, Messrs. G. and J. Weir, Ltd., the medical officer and his assistants did not get such a clear-cut impression. In the Burns Ward at the Royal Infirmary the relief obtained from application of the orthoform cream was also somewhat variable. It was noted that many of the burns on arrival at hospital within half an hour to 2 hours did not complain of pain.

No toxic effects were observed from the use of these analgesics but they were not applied to extensive burns. We are informed by Lt.-Col. J. Barrett Brown, of the U.S. Army Medical Service, that such effects have been reported in America, particularly with percaine.

(b) Preventing Infection

One event is especially to be feared in connection with every fresh burn, namely, infection of the surface by the haemolytic streptococcus. If this does not occur the great majority of superficial burns heal within 7–20 days ; if it does occur the damage to tissues is usually increased, healing may be much delayed, and, if the burned area involves flexures, contractures are likely to result.

In some cases a spreading cellulitis or lymphangitis may develop and constitute a threat to life. The late deaths (after the fourth day) are not infrequently due to such an invasive infection. Staphylococcal infection of the fresh burn may also be troublesome and delay healing, but seldom has such serious consequences as those due to streptococci.

Under the existing haphazard arrangements for first aid to burns both these infections are very common. Table I shows the incidence of streptococcal contamination of 516 burns on arrival at the Glasgow Royal Infirmary (1942–3). Within the first 12 hours after burning only 4 per cent. yielded haemolytic streptococci—and the proportion of positives was considerably lower for cases examined within 3 hours. After 12 hours the proportion of infected cases rises steeply.

TABLE I

Number of hours after injury	Number of burns examined	Haemolytic streptococci present
0–12	370	15=4·05 per cent.
12–24	39	9=23·1 ,,
More than 24	107	45=42·05 ,,

Of all the minor burns treated as out-patients 30 per cent. were infected with haemolytic streptococci at their first visit to the hospital.

The primary object of all first aid to burns should be the prevention of these streptococcal infections. It should seek, in the first place, to prevent the arrival of any streptococci on the burned surfaces ; and, if they have already arrived there, it should seek to destroy them or at least to prevent their multiplication.

How to prevent the arrival of Haemolytic Streptococci on the Burned Surfaces

Haemolytic streptococci are rarely found on normal human skin (see below) ; and it follows, therefore, that those which infect burns must usually be derived from sources other than the patient's own skin.

Colebrook, Maxted and Morris Johns (1935) isolated haemolytic streptococci (group A) from only 7 of a group of 181 factory workers, and the circumstances suggested that in some of the 7 the organisms might have come there from the respiratory tract. The same authors failed to isolate any group A strains from the perineum and thighs of 160 parturient women. Hare (1941) in Canada isolated only one group A strain from the hands of 248 students. Colebrook (1930) also showed that when haemolytic streptococci were experimentally dried on the skin of the hands they did not remain viable for more than a few hours.

It is not difficult to visualize the many sources from which burns may acquire these infecting cocci. Haemolytic streptococci are widely distributed in all human communities of the temperate zones, being associated with, and continually disseminated from, many common infectious processes, e.g. cellulitis and septic sores, erysipelas, impetigo, whitlows, scarlet fever and tonsillitis, otitis media and chronic ' running ears ' of childhood, puerperal fever, etc. In addition they are present in the nasopharynx of many healthy carriers (5–30 per cent. of the population) who project them into their environment by coughing, sneezing, etc. Less commonly they proliferate in the nose of nasal carriers, and these individuals are especially dangerous because of the continual seepage on to handkerchiefs, clothes, hands, etc. From all these sources haemolytic streptococci find their way into the air of public places and private houses; they remain viable for long periods in dust and are freely disseminated by the sweeping of floors and the shaking of blankets and other bedding. (Thomas, 1941; Colebrook *et al.* 1944.)

Finally, it should be noted that, although haemolytic streptococci cannot survive in the acid secretion of normal skin, they multiply very rapidly in the serous exudate of burned surfaces and commonly persist there for long periods.

Clearly it will not be easy to prevent the fresh burn from contamination from so many potential sources ; and without strict precautions first-aid

procedures may themselves provide the medium for such contamination. There can be little doubt that in the past they have often done so.

First-aid personnel should wear efficient masks covering the mouth and nose, or, if these are not available, a clean handkerchief will serve. The burned surface should be covered *as soon as possible* with a sterile cloth or at least a recently laundered clean towel. Blankets are seldom sterilized at the laundry and therefore are very apt to be contaminated with pathogenic organisms, including haemolytic streptococci. *They should on no account be allowed to touch the burned surface.*

The hands of first-aid personnel should be carefully washed *for at least 2 minutes*, and then dried on a clean towel, before any treatment of the burn is undertaken.

If the burn is extensive and cannot be exposed without removal of clothes, the patient should be sent straight to hospital without any first-aid dressing of the surface.

How to deal with Haemolytic Streptococci which have already arrived on the Burned Surface

First aid should include a minimum of interference with the burned surface because the conditions will seldom be such as to allow of strictly aseptic procedure. For this reason the burn should not be washed nor should blisters be snipped.

The bactericidal or bacteriostatic agent employed should be in the form of a water-soluble cream which can be easily washed off during the subsequent plenary treatment, rather than a jelly or coagulant solution, such as tannic acid, which will be difficult to remove. Bactericidal dyes, like gentian violet, although they may have advantages in some special circumstances, e.g. on small ships, are not recommended for general use because they prevent the medical man who subsequently treats the case from forming any opinion as to the depth of the burn. They are also highly toxic to the already injured skin tissues, and cannot be washed off during plenary treatment. They cannot be relied upon to sterilize the burned surface with certainty.

Of the anti-bacterial agents available at present the new synthetic detergent, cetyl trimethyl ammonium bromide ('Cetavlon') seems likely to be the most effective for the first-aid treatment of burns. Barnes (1942) showed that, in addition to its cleansing effect on normal skin, it was remarkably effective in getting rid of 'resident' organisms—apparently reaching those in the depths of sweat and sebaceous glands and hair follicles more successfully than the substances previously employed as skin antiseptics. Our own experiments and those of Williams *et al.* (1942) have confirmed this, and also the fact that Cetavlon has a rapidly lethal action on haemolytic streptococci. Because of its toxic action on leucocytes and tissue culture cells (Barnes, 1942; Jacoby, 1943) it cannot be regarded as the ideal substance to apply to tissues which we want to regenerate, but in actual practice with burns the risk of any toxic effect has proved very slight. Apart from three instances of sensitization-dermatitis (see note below) no irritant effects have been observed among the two thousand burns to which Cetavlon has been applied in Glasgow during 1942–3; nor has it seemed to delay healing.

Cetavlon also has the disadvantage of being a potent protein precipitant, and thereby forfeits much of its anti-bacterial potency in presence of the serous exudate of burns. As shown in Table 2, however, this anti-bacterial effect is by no means abolished by serum or blister fluid. Pending the discovery of an equally potent anti-bacterial substance which is free from these defects Cetavlon appears to be the most suitable one for the first-aid application to burns. By virtue of its powerful detergent properties it will remove most of the detachable organic material from the burned surface and surrounding skin, and thereby greatly facilitate the destruction of bacteria. It is, moreover, not incompatible with sulphonamides, so that these two anti-bacterial agents can be combined in a first-aid cream.

Such a combination seemed desirable for two reasons: (1) because the bacteriostatic effect of the sulphonamide would reinforce that of the Cetavlon, and (2) because sulphonamide was likely to be more effective than Cetavlon in controlling an infection by haemolytic streptococci which had *already invaded the tissues*, e.g. in burns several hours old when first seen.

Several such combined creams were prepared for trial at the Glasgow Royal Infirmary by one of us (J. P. T.). The most satisfactory one ('No. 9 Cream') had the following composition:

Cetyl trimethyl ammonium bromide	1 gm.
Sulphanilamide	10 ,, *
Castor oil	25 ,,
Beeswax	1·8 ,,
Wool fat	1·8 ,,
Cetyl alcohol	5 ,,
Glycerin	10 ,,
Water	45·4 ,,

It is prepared as follows: Melt the castor oil, beeswax, wool fat and cetyl alcohol *at as low a temperature as possible*. Dissolve the Cetavlon in the water with the aid of heat and mix with the oil, etc., at about 60° C. and stir till set. The sulphanilamide is then rubbed up with an equal weight of glycerin, the two together comprising 20 per cent. of the final product. This sulphanilamide-in-glycerin is then incorporated in the cream and

* *Recent batches of No. 9 Cream have contained only 3 per cent. of sulphanilamide.* This reduction was decided upon when it was found that a toxic dose of the drug may sometimes be absorbed from extensive burns dressed with the 10 per cent. cream. (Contrary to our expectations this excessive absorption occurred in patients with deep, heat-tanned burns rather than in second-degree burns.) Excessive absorption from a 3 per cent. cream would be very unlikely. Even if as much as 300 gm. were used for a single application it would contain only 9 gm. of sulphanilamide. Only part of this would be absorbed, and its absorption would be spread over several hours; part would seep away into the dressings after solution in the exudate; and some would probably remain undissolved. On the other hand, 3 per cent. of sulphanilamide is probably more than enough to give the desired prophylactic effect.

thoroughly mixed. A Peerless Mixer with bent arm at slow speed has given the best results, but it is quite possible to make the preparation by hand, although not quite so well.

(NOTE.—*This cream cannot be heated to sterilize it*, but it can be regarded as self-sterilizing for the ordinary non-sporing pathogens. Samples experimentally contaminated with staphylococcus aureus, B. proteus and Ps. pyocyanea have always been found free from viable organisms after 24 hours. It is possible that spores of pathogenic clostridia, including tetanus, might survive in it (this point is being investigated), but the risk of such contamination may be regarded as extremely small. When the cream is to be kept for long periods chlorocresol (0·2 per cent.) should be added to it to prevent any growth of moulds.)

In vitro Tests with No. 9 Cream and other First-Aid Remedies in common use

To find out how much bactericidal or bacteriostatic effect was to be expected in the presence of a copious exudate of blister fluid on the surface of a burn, tests were carried out as follows:

1 c.c. volumes of blister fluid (if available), or of serum, were inoculated with staphylococci and haemolytic streptococci, and then vigorously shaken with a large loopful (40 mg. approx.) of the cream or other first-aid remedy. Viable counts were made (with adequate dilution but without chemical neutralization of the bactericidal agent) before the addition of the test substance, and again after 24 hours incubation with it at 37° C. Typical results are shown in Table 2 :

It is seen that:

(*a*) In blister fluid alone staphylococcus aureus and haemolytic streptococcus multiplied freely. (This is not the case with some of the non-pathogenic ' micrococci ' normally resident on the skin.)

(*b*) In presence of No. 9 Cream and the dye-jellies used these organisms were killed off.

(*c*) In presence of tannic acid, phenol had not any antiseptic action, while acriflavine also was largely neutralized, allowing staphylococcus to grow out, although streptococcus did not.

By this test No. 9 Cream appears at least as satisfactory as the jellies containing bactericidal dyes, and it has the important practical advantage over these that it can be readily washed off for the plenary treatment, allowing the medical man to estimate the depth of the burn.

It is recognized that these *in vitro* tests as performed do not reflect exactly what would happen on the surface of a fresh burn, because they take no account of any fixation of the antiseptic agent by the tissue cells of the burned surface. Other observations, which will be reported elsewhere, showed that washing over a fresh burn (i.e. not more than 24 hours old) with Cetavlon solution did usually reduce the bacterial contamination of the surface from a matter of ' thousands ' to nil or almost nil. We think it may be presumed that a similar effect will be obtained with No. 9 Cream.

Clinical Trials of First-Aid Creams

Following upon these tests in the laboratory observations were made upon two series of minor burns attending Glasgow Royal Infirmary in order to determine if possible how far the application of the creams was preventing infection by haemolytic streptococci.

Series I. Two creams were used, viz. No. 9 as described above, and a simpler one, ' Cetavlon Cream,' containing no sulphanilamide. Its composition was: cetyl trimethyl ammonium bromide 1 gm., cetyl alcohol 5 gm., linseed oil 25 gm., water 69 gm.

TABLE 2

	Staphylococcus aureus		Haemolytic streptococcus	
	Before incubation	After incubation	Before incubation	After incubation
Experiment 1.				
Blister fluid alone	80,000	18,000,000	19,000	13,000,000
Blister fluid+' Tannafax ' (tannic acid+phenol, 0·5 per cent.) ..	80,000	2,000,000	19,000	600,000
Blister fluid+No. 9 Cream	80,000	0	19,000	0
Blister fluid+' Triofax ' (gentian violet, 1 per cent.+brilliant green, 0·1 per cent.+euflavine)	80,000	0	19,000	0
Blister fluid+gentian violet jelly (gentian violet, 1 per cent.+merthiolate, 0·02 per cent.)	80,000	0	19,000	0
Experiment 2.*				
Serum alone	300,000	10,000,000	150,000	15,000,000
Serum+tannic acid+acriflavine, 0·1 per cent.	300,000	2,000,000	150,000	0

* In this experiment No. 9 Cream, ' Triofax ' and gentian violet jelly gave the same result as in experiment 1.

Consecutive cases (not severe enough for admission) were treated as follows at their first attendance: A moist swab (A) was rubbed over the burned surface for subsequent bacteriological examination. Blisters, if present, were not opened nor epithelial debris removed; nor was any attempt made to clean up the burned surface in order to remove the substances previously applied—caked flour, vaseline, semi-coagulated jellies, etc. After being dressed with one of the two creams, covered with gauze, wool and a bandage, the patient was told to report next day at the out-patient burns clinic. Here a second swab (B) was taken for bacteriological examination, and the burn then received its full or plenary treatment *—blister skin being removed, the surface gently cleaned with Cetavlon solution and a sulphanilamide dressing applied. Eighty-two patients were treated in this way with Cetavlon cream and sixty-two with No. 9.

The clinical results of these trials were very satisfactory—the dressings having been comfortable from the first in the great majority of cases, and the burned surfaces either healed or almost healed when the patients came back after one week.

The bacteriological evidence as to the control of infection is shown in Table 3 :

TABLE 3

Group 1. Cases in which cream was applied within 24 hours of the injury. Total 119	Cetavlon Cream	No. 9 Cream
Did not become infected with H.S. (haemolytic streptococcus)	66	42
H.S. present in first and second swabs	2†	4†
H.S. present in first swab but did not persist	0	1
Became infected with H.S. after application of cream	4‡	0
	72	47
Group 1*a*. Cases belonging to Group 1, but in which the second swab was taken *more than* 24 *hours after injury*. Total 68		
Became infected with H.S. after application of cream	4‡	—
Approximate number in which H.S. infection *was to be expected* after 24 hours (see Table 1) if cream had not been applied	20 to 30	
Group 2. Cases to which cream was applied 24 hours or more after the injury. Total 25		
Did not become infected with H.S.	6	6
H.S. present in first and second swabs	2	8**
H.S. present in first swab but did not persist	0	0
Became infected with H.S. after application of cream	2††	1§
	10	15

* It should be made clear that the above procedure was adopted only to obtain evidence as to its efficacy in preventing infection by streptococcus. If this object had not been in view the plenary treatment would have been carried out at the first visit to hospital.

† Of these 6 cases, 3 had been burned 21 hours or more before the cream was applied, so that invasion of the tissues had probably begun.

‡ One of these had been covered with lanolin and another with flour, which may have prevented effective contact of the cream.

** These patients had been burned respectively 27 hours, 2 days (2 cases), 3 days (2 cases), 3½ days, 5 days and 7 days.

†† One of these burns was covered with ointment, the other had a heavy coagulant dressing of gentian violet, which probably prevented satisfactory contact of the cream.

§ This is open to doubt; the first swab gave a confluent growth of staphylococcus in which a few haemolytic streptococcal colonies could easily have escaped detection.

The data in Table 3 suggest the following tentative conclusions:

(1) That temporary dressing of the burns with cream in the 68 cases of group 1a did to some extent prevent their becoming infected with haemolytic streptococci. In view of the figures in Table 1, it seems reasonable to suppose that many more than 4 of these 68 cases would have been so infected after 24 hours if they had been left alone. (It must, however, be admitted that *any* sterile dressing would have had some protective effect.)

(2) That the creams used were not usually successful in getting rid of the haemolytic streptococci already present on the burned surfaces at the time of the first swab. The failure to get rid of them in 6 cases out of 7 should, however, be viewed in the light of footnote.† It may well be that we should have had more success if all the cases had been burned only a short time and if the burns had not been smeared with 'white ointment,' vaseline, jellies, etc., before the cream was applied. The failure to eliminate haemolytic streptococci from burns to which our creams were applied late, i.e. more than 24 hours after injury, did not surprise us, because Barnes had previously shown that Cetavlon did not reduce the bacterial count of a granulating surface, and our own experience with definitely infected burns had confirmed this many times. Once the streptococci have invaded the tissues Cetavlon is probably of little or no use.

Series II. In this series of 104 minor burns only No. 9 cream was used and the procedure was modified slightly in the hope that we should get still better control of infection. The various applications made before coming to hospital were removed as far as possible; a swab (A) was then taken for bacteriological examination; blisters were usually emptied (but blister skin *not* cut away); the burned areas were then washed over with Cetavlon solution, and No. 9 cream applied for periods varying from 12 to 48 hours. The second swab (B) was then taken and the usual plenary treatment applied.

Seventy-three cases were free from streptococci when they first came to the hospital (A swab) and none had acquired them when the B swab was taken 20–40 hours later—with two exceptions, for which there was a sufficient explanation. One of these

was a boy who did not reappear for 7 days after the first-aid treatment was applied; the other, a child which pulled off its dressing before it came back for the second swab.

Of the 31 patients who already had haemolytic streptococci in the A swab, 8 had lost them before the second swab was taken—presumably as a result of the first-aid treatment. Of the remaining 23 patients, who did not lose their streptococci, 20 had been burned more than 24 hours before they came to hospital and 2 of the others were burned 16 and 20 hours respectively before treatment.

These results certainly suggest that the cream and the Cetavlon solution were effective in holding off streptococcal infection in this series of burns.

Commentary upon these Clinical Trials

1. We do not claim to have proved conclusively that the first-aid procedures adopted have prevented infection by streptococci, although we think that the findings point to a large measure of success and warrant a more extended trial of the methods.

2. A random series of hospital patients, some of whom have been burned many hours or even days before, and have had divers applications, cannot yield clear-cut results. Future comparative trials of first-aid remedies should be made on fresh burns which have had no previous treatment.

3. Medical officers of large industrial organizations, e.g. foundries where many minor burns occur, in collaboration with a bacteriological laboratory, could obtain valuable data by comparison of cases treated with No. 9 or other antiseptic cream, with other cases treated with the same cream without the antiseptic.

Note on Sensitization to Cetavlon

In the course of this work we have encountered three instances of severe vesicular dermatitis apparently induced by the application of Cetavlon. In two of these the condition developed after the Cetavlon cream had been in contact with the burned areas for several days (12 days in one case) ; in the remaining case the solution of Cetavlon had been applied to the skin on only three occasions and the dermatitis developed 7 days after the third application. In all three the condition cleared up within 2–3 weeks, after becoming more or less generalized and associated with some degree of toxic disturbance. A scratch test with a 1·5 per cent. solution of Cetavlon gave a definite positive result in all three cases after the dermatitis had cleared up. A similar test with potassium bromide in two of the cases gave a negative result. Potassium bromide by mouth in one case produced a slight eruption.

One of the patients has had two recurrences of the dermatitis at intervals of several months—one of them definitely induced by accidental contact with Cetavlon.

These three are the only cases of dermatitis we have met in a total of more than 2000 burns to which Cetavlon has been applied at the Glasgow Royal Infirmary. We are informed by Dr. R. G. MacFarlane that a 1 per cent. solution has been used for cleansing the skin of some 2160 blood donors in the West of England and that no dermatitis has been reported to date.

Conclusions

1. The avoidance of infection by haemolytic streptococcus should dominate first-aid policy for all but very severe burns. In the latter, measures for the preservation of life will often have to take precedence over local treatment of the burn.

2. For most small burns which are accessible, e.g. of the hand or forearm or head, first aid at the scene of the accident should usually be limited to covering with a recently laundered clean towel, or, better, if it is available, with a sterile cloth. (Wherever burns are likely to occur such cloths should be kept ready, previously sterilized in an oven and stored in a tin.) The burn thus covered should be sent at once to the factory surgery, or a hospital, or a private doctor.

In all severe or extensive burns no first aid should be attempted other than keeping the patient warm and giving morphia if required. Immediate removal to hospital is the first consideration.

3. When quite superficial small burns are treated at home or when, in the case of more severe burns, the plenary treatment cannot be carried out without considerable delay, it is recommended that the burned area, and the skin around, should be freely smeared with a water-soluble cream containing 1 per cent. of cetyl trimethyl ammonium bromide (' Cetavlon ') and 3 per cent. of sulphanilamide. This cream should be applied with a knife blade or spoon, previously sterilized by dipping for 2 minutes in boiling water. The burn should not be washed before the cream is applied nor should blisters be snipped.

This first-aid treatment must be carried out with due precautions against the transfer of streptococci to the burned surface. Thus, the operator's hands must be thoroughly washed and dried; and he should wear a gauze mask or a clean handkerchief over his mouth and nose.

After smearing with the cream the burn should be carefully wrapped in sterile lint and a bandage, or in a recently laundered clean towel.

On no account should blankets be allowed to come into direct contact with the burn (because they are frequently heavily contaminated with pathogenic organisms).

4. The cream should not as a rule be left on the burn for more than 2 days because there is a slight risk of inducing dermatitis if left longer.

In special cases, e.g. in a small ship, or in shipwrecked persons, this small risk will be of no account in comparison with the much greater risk of infection if the burn is not treated.

5. The inclusion of a local analgesic in the first-aid cream is not recommended—for the following reasons:

(*a*) It is unlikely to give sufficient relief for a severe burn, which will usually require morphia.

(*b*) The pain of many small burns is so transient as to need no analgesic.

(*c*) The relief of pain by local analgesics is uncertain, and often short-lived.

(*d*) There is some risk of toxic effects from the use of local analgesics on a large burned area in susceptible individuals.

Acknowledgements

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BURNS OF THE HAND *

BY

P. H. JAYES

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It is incumbent upon the industrial medical officer to acquaint himself fully with the modern treatment of burns, and to pay special attention to burns of the hands. Burns of the exposed areas of the body, especially the hands, frequently occur among factory workers and it is of paramount importance that these cases should receive expert treatment from the earliest stages. In many instances only a small percentage of the body surface is involved and there is very little disturbance in the general condition of the patient. But if the hands are affected vital issues are at stake. Errors of treatment may result in persistent stiffness, contractures, and permanent disablement; whereas proper care and attention can restore full function in the majority of cases even when the skin of the entire hand is destroyed.

In recent years many different methods have been advocated for the treatment of burns and fantastic claims have been made for a wide variety of lotions and ointments. It must be realized that successful results are dependent on close observance of the fundamental principles of wound treatment rather than on the application of a specific chemical substance. The choice of dressing for a burn varies under different circumstances but provision must always be made for free surgical drainage and the early separation of dead tissue. Furthermore, the technique adopted must aim at the control of infection combined with the preservation of function in joints and tendons.

First- and second-degree burns heal satisfactorily with almost any method of treatment, but third-degree cases present many difficulties and are the crux of the whole problem. In these cases skin replacement is perhaps the most important single factor in treatment. If a burn results in a loss of skin on the hand or fingers extending over an area of more than a few square centimetres, a skin graft must be applied at the earliest opportunity to ensure a full functional result. Unless the skin which has been destroyed is replaced by a graft, healing can take place only by epithelium gradually growing in from the edges of the affected area until the whole surface is covered. This is a slow process and inevitably results in contractures and crippling deformity. Any method of treatment which is advocated for third-degree burns must be regarded with suspicion unless it encourages the removal of sloughs and enables raw surfaces to be grafted successfully at an early stage.

Industrial burns of the hand are commonly localized, in contra-distinction to war burns which usually involve the entire hand. Many procedures which are advocated for encircling burns must be modified when the localized type is under consideration. Prognosis for function is dependent on the distribution of the burn as well as on the extent and depth of tissue destruction. Burns which affect the palm and flexor surfaces of the fingers are generally more serious than burns confined to the dorsum of the hand.

First-Aid Treatment

If the burn is of sufficient severity to necessitate hospital treatment, first-aid measures are confined to a minimum. The affected areas are covered with sterile gauze dressings (or clean linen, if sterile dressings are not available) and the patient transported to hospital as quickly as possible. In this country the patient can always be admitted to hospital within an hour or two of the accident and there is no indication for elaborate first-aid treatment. Attempts at cleaning or the application of ointments under such conditions increase the risks of infection and serve no useful purpose.

Treatment on Admission to Hospital

The patient must be examined and the treatment carried out under full aseptic conditions. Under morphine analgesia the affected areas are thoroughly but gently cleansed and for this purpose 1 per cent. 'Cetavlon' solution (cetyl-trimethyl-ammonium bromide) is most useful. Cetavlon is a detergent antiseptic solution which has considerable bactericidal power, and it deals effectively with any pathogenic organisms which are present on the surface of the burn or surrounding skin. Blisters are opened and loose epithelium carefully trimmed away with scissors. The burn is covered with a single layer of tulle gras, and them gauze wrung out in normal saline is applied and kept in place with bandages. The fingers must be dressed individually, opposing raw surfaces being kept apart by the dressings.

* A paper read at a meetin of the Association of Industrial Medical Officers, January 22nd, 1944.

This treatment should be carried out quickly with as little exposure of the burns as possible. General anaesthesia is usually unnecessary and should be employed only in exceptional circumstances, for example when required for associated injuries.

Subsequent Treatment

1. **Dressings.** If the general condition of the patient is poor the initial dressing is sometimes allowed to remain in position for three to four days but thereafter the dressings are changed twice daily. The outer layers of gauze are removed and the hand is immersed in normal saline at 100° F. If the burn is confined to the hands, arm baths are used but when the burn also involves other parts of the body a total immersion bath is more convenient. In the bath the gauze and tulle gras float away from the raw surfaces and the patient suffers very little discomfort from removal of the dressing. Epithelial debris and grease tend to collect at the margins of the burn and gentle swabbing is required to keep the whole area scrupulously clean. The time of immersion varies with the individual case, but after approximately 30 minutes the hand is withdrawn from the bath and a dressing of tulle gras and gauze wrung out in saline again applied.

2. **Splinting and Elevation.** With burns of the hand oedema is a prominent feature in the first few days and it is necessary to elevate the limb until the oedema has subsided. The hand is placed on a splint (plaster-of-paris or malleable metal) and the splint suspended from a Balkan beam to give the required elevation. The hand is splinted in the position of function, but this position will vary according to the distribution of the burn. When the entire hand is affected the fingers are placed in half flexion at the metacarpophalangeal and interphalangeal joints, the tip of the thumb being in apposition with the index finger. When the burn is confined to the flexor surface the fingers and wrist are placed in the extended position. Great attention must be paid to these details for if any stiffness occurs the disability will be minimal if the hand has been treated in the position of function.

3. **Movement.** It is advisable to keep the fingers at rest until the oedema has subsided, but throughout the remaining period of treatment much emphasis is placed on *active* movement. The saline

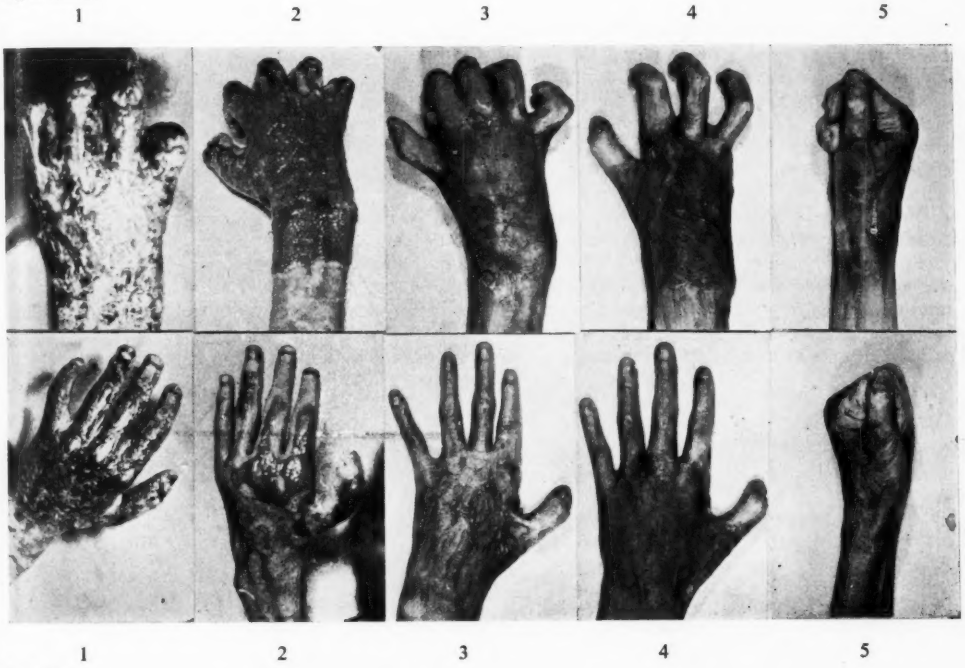

FIG. 1.—Severe third-degree burns of both hands—palms not involved.

Right hand.—1. Extensor tendons exposed and proximal interphalangeal joints open. Sloughs still present. 2. Raw surface ready for grafting. 3. Completely healed after application of large graft. Fifth finger hyperextended—amputated later. 4. and 5. Result. Proximal interphalangeal joints ankylosed in good position. Full movement in metacarpophalangeal joints. Grip good. Useful hand.

Left hand.—1. Extensor tendons exposed but joints *not* involved. 2. Tendons covered by granulation tissue. 3. Healed but scar tissue is tight and unstable—webs contracted. Movement at metacarpophalangeal joints limited by tight scar. 4. and 5. Result. Full movement following replacement of scar by graft.

bath is a great help in the preservation of function as finger exercises can be performed with little discomfort while the hand is immersed in the saline.

In some third-degree burns the extensor tendons are exposed in the fingers, and occasionally the tendons are destroyed over the proximal interphalangeal joints. Division of the extensor expansions at this point results in exposure of the joints and ankylosis usually occurs later. In these cases it is very important to splint the fingers in the position of function, otherwise they become fully flexed owing to the unopposed action of the flexors and ankylosis takes place in the flexed position with disastrous consequences from the functional standpoint.

Complications of this type may necessitate splinting for an extended period but the average burn of the hand is only immobilized for two or three days while the oedema is subsiding; the patient is then encouraged to move his fingers as much as possible. With this regime 'the frozen hand' is never seen and final healing is frequently coincident with a full range of movement in the fingers.

4. **Preparation of Raw Surfaces for Grafting.** One of the advantages of the saline method is that sloughs separate rapidly so that most third-degree burns are ready for grafting by the twenty-first day. Grafts cannot be applied until all dead tissue has been removed and healthy granulations are present. The granulations should be flat, firm and pink in colour with the epithelium growing in rapidly at the edge of the raw area. If they are oedematous, hypertrophic and spongy it is useless to apply grafts as these will float off in the pus which exudes from the surface. The bacteriology of the wound is determined and efforts are made to control infection before operation is undertaken. The organisms most frequently present are haemolytic streptococci, staphylococci, B. pyocyaneus and B. proteus. Streptococcal infection is the most frequent cause of failure of grafts. The local application of sulphanilamide powder to the burn is often successful in getting rid of haemolytic streptococci, but some strains of this organism are resistant to the drug. Sulphanilamide-resistant streptococci can usually be eliminated with propamidine or penicillin, but the latter substance is not yet available for routine use.

Although in some cases it is necessary to employ special drugs, as a general rule raw surfaces can be prepared for grafting by the method already described without additional aids. Success is largely dependent on a careful dressing technique and the prevention of cross-infection.

5. **Grafting.** Skin replacement is so important in the hand that all raw areas should be grafted as soon as possible, irrespective of their size. Split skin grafts are placed on the raw surfaces and covered with tulle gras, wool and gauze. The dressings are fixed with a crepe bandage and remain in position for about five days. At the end of this

FIG. 2.

1. Healed burn—tight, unstable on dorsum of hand with limitation of movement. 2. Removal of scar. 3. Cutting of graft with Padgett dermatome. 4. Graft sewn in position. 5. and 6. Result—full function.

time the grafts are inspected and if they have taken successfully healing will be practically complete. The hand is covered for a few more days while the new skin is consolidating, and exercises and active movements are continued.

6. **Restoration of Function**. A patient with first- or second-degree burns should be able to move his fingers through their full range as soon as the skin is completely healed. If there is residual stiffness it is a serious reflection on the treatment of the case. Limitation of movement at this stage is usually attributable to prolonged and unnecessary immobilization in the preceding period and the surgeon rather than the patient should be blamed.

With third-degree burns, although the primary object is to obtain a completely healed hand, the treatment continues until maximum function is present and the patient is fit to return to work. In some cases an intensive course of physiotherapy is required before the patient regains full power in the hand with proper co-ordination in finger movements. The methods used to help restore function include active exercises, paraffin wax baths, and occupational therapy of a suitable type. Passive movement or manipulation of the fingers is never permitted under any circumstances.

7. **Late Surgical Treatment**. The surgical treatment of burns of the hands should be considered in two separate phases. In the early period grafts are used to cover raw areas and expedite healing, and in the late stages operation may be required to relieve contractures and improve function. The initial grafting is done in the third or fourth week, but no further operative treatment is usually contemplated until two or three months later. At this stage the case is reviewed and if function is still impaired operation is frequently indicated. Persistent limitation of finger movement is often caused by tight scars and insufficient skin on the dorsum or palm of the hand, and in these cases the patient will be greatly improved by the insertion of a graft. The other indication for grafting is thin, unstable scar tissue at the site of the burn which breaks down on the slightest injury, so that while a full range of movement may be present, incapacity is just as marked as in the cases where there is limitation of movement. Replacement of such unstable scars invariably produces the desired result.

The late operative treatment of the burned hand sometimes includes other procedures such as capsulotomy, arthrodesis, and tendon repair, but space does not permit discussion of these methods.

I am greatly indebted to my teacher Mr. A. H. McIndoe for much help and encouragement in the preparation of this paper.

PREVENTION AND CONTROL OF CUTTING-OIL DERMATITIS

BY

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Of the chief industrial hazards to which employees in this country are exposed, the one to show the greatest increase during the past few years as regards numbers affected is dermatitis 'caused by dust or liquids.' One of the obvious reasons is related to the marked increase in the number of workers who are engaged in the heavy industries, engineering and munitions, and therefore in contact with various kinds of skin irritants. In a large engineering establishment where the writer is medical officer, the chief industrial hazard is oil dermatitis. The methods and measures adopted to control this hazard, and the results obtained during the past three years, may therefore be of interest.

Types of Oil

The three commonest types of oils with which workers come in contact are soluble oil, lard oil and paraffin oil. These are used on the engineering side as follows. Soluble oil, which is water soluble, is used as a coolant in operations where great heat is generated. Lard oil is used as a lubricant and in operations where the sharp edges of the tools have to be preserved. Paraffin oil is also used as a lubricant and as a degreasing agent in the form of a wash.

There are various types of soluble oils used in engineering establishments and the one most commonly in use at the writer's factory consists of a mineral oil and animal or vegetable oil with the addition of an emulsifier, such as soap. A trace of a phenolic disinfectant (p. tertiary amyl phenol) is added by the supplier.

Analysis of this type of oil reveals the following:

Saponifiable matter	3·00	per cent.
Unsaponifiable matter ..	*84·10	,,
Ash	1·07	,,
Water (by difference)	11·83	,,
Acid value	4·9	,,
*Contains fatty oils	12·6	,,
Sp. Gr. at 18° C.	0·940	,,
Phenols	Present	

As already mentioned soluble oil is used for its cooling properties and in the strength of a 4 per cent. solution appears as a whitish opalescent mixture. Of the three oils in use, soluble oil has led to least trouble regarding the incidence of dermatitis. Lard oil is used neat and contains 40 per cent. mineral oil and 60 per cent. pure lard oil. No sulphur or soluble disinfectants are present, as in some lard oils used in other branches of engineering. Paraffin oil is also used neat and a sample taken from bulk stock reveals the following:

Sp. Gr.	0·800
Organic acidity	Nil
Inorganic	Nil

Effects Produced

The commonest type of oil dermatitis seen during the past three years has been an oil acne caused either by lard oil itself or a mixture of lard oil and paraffin oil. As a result of the mechanical blocking of the sebaceous glands and hair follicles, chiefly of the arms and legs, papules form which, if they remain untreated or are further exposed to the irritating effects of the oils, become complicated in the form of folliculitis which if carried a stage further can go on to furunculosis.

The chief types of lesions produced by soluble oil are, in more acute cases, a diffuse macular and papular rash over the arms and legs; in more chronic cases an oil acne, which is usually not so marked as that produced by lard oil. Paraffin oil dermatitis takes the form, in the first stage, of an erythema of the area in contact with the oil. If allowed to go untreated, the skin becomes dry and fissures may form. In other cases, desquamation of the skin occurs; a more severe degree results in vesiculation on the erythematous area. The commonest sites for oil dermatitis are on the forearms and anterior aspects of thighs and legs, and around the anterior aspects of the elbows.

As already mentioned, the chief factor of the production of oil dermatitis or oil acne is the mechanical blocking of the sebaceous glands and hair follicles. This is largely contributed to by neglect of personal cleanliness and by the friction of oil-soaked overalls on the arms and legs. In the cases of paraffin and soluble oils, where the arms and legs may be wetted for a considerable period of time by contact with the oils, the wetting results in a weakening of the resistance of the skin and the onset of a diffuse macular and papular rash over the areas.

Prevention

The chief measures which have been adopted, are —(1) selection of suitable employees; (2) education of the workers; (3) measures on the job.

Selection of Suitable Employees. All employees before being interviewed by the staff of the Labour Department fill up a form which asks, among other things, whether the individuals have had a previous attack of dermatitis; its duration; if it was sufficiently serious to incapacitate them from work; period of incapacity; and whether compensation was successfully claimed or not. In the medical examination of suitable applicants for work, points which are looked for are, (1) good thickness of skin, (2) the skin not to be too dry or too greasy, (3) no evidence of skin lesions.

It is well recognized that an attack of dermatitis caused by a specific irritant, whether physical, chemical or bacterial, sensitises the skin and makes individuals more susceptible to further attacks if they continue to be in contact with skin irritants. Individuals who apply for work where they will be in contact with oil and who give a previous history of dermatitis which has incapacitated them for some time (weeks or months), whether industrial or non-industrial in origin, are therefore recommended for a type of work, if available, where they will not be in contact with oils. This is particularly the case where the workers are fair-haired and pale or red-skinned. It is the writer's experience that such individuals have skins which are more sensitive to irritants than those of darker brown-skinned persons. This question of sensitization of skin, with increased susceptibility to further attacks of skin trouble, is well illustrated by the following case.

M. McL. was first seen on 1.11.40 when she gave the following history. Six years previously, when she was working in a bakery, she developed dermatitis of the face, arms and neck, caused by sugar and flour with which she was in contact. She was off work for 6 weeks and received compensation. She started work on 3.6.40 before pre-employment selection had been instituted and, working at that time with soluble, lard, and paraffin oils, she soon developed acute pustular dermatitis of both arms with a papular dermatitis of the face. She was suspended from work and was off work for two years. Her second attack of occupational dermatitis proved most resistant to all forms of treatment.

Education of the Workers. Propaganda regarding preventive measures starts as soon as the successful applicants are ready to commence work when they are given a leaflet stressing the following points:

Personal Cleanliness.—They are advised to wash, particularly their hands and forearms, at tea breaks and at meal times. Ample facilities for washing with hot and cold water are available for all employees.

Protective Lotions.—The leaflet also advises all employees that protective lotions are supplied free from every first-aid room in the factories. If working with soluble oil, they should ask for Alkaline Wash; if working with paraffin oil, they should ask for what the writer calls Dermis Wash, to contrast with Alkaline Wash. The respective formulae of these washes are:

Alkaline Wash

Chlorinated Lime	grains 175
Soda Bicarb. Crystals	„ 350
Acid Boric Crystals	„ 35
Aq. ad.	oz. 30

Dermis Wash

Ivory Soap Flakes	7·48 per cent.
Glycerine (chemically pure)	26·40 „
Sodium Silicate	24·20 „
Tragacanth	0·21 „
Oil of Lemons	0·16 „
Water	41·60 „

The paste thus formed is dissolved in water in the proportion of 2½ lb. of paste to 2 gallons of water.

Further advice is given in the leaflets to use these washes after getting home from work and before starting out in the morning, as follows:

1. Dilute the wash 1 part to 10 parts of water.
2. Apply the wash to your hands, arms, etc.
3. Wash your hands, arms, etc., with hot water and soap (not carbolic). Dry them thoroughly.

This will remove all traces of oil from your skin and will prevent the onset of dermatitis.

N.B.—Oil dermatitis is not infectious.

By means of these leaflets all workers who will be in contact with oil are made aware, from the first day they start, of the value of personal cleanliness and of the availability for all who need them of protective skin lotions In spite of the large number of barrier creams and ointments at present on the market, the writer has not found anything the action of which is better than these lotions.

Overalls.—In February 1941 when the system of distribution of overalls was changed, the opportunity was taken to give all workers a leaflet with their new overalls, stressing the importance of changing overalls at least once a week and stressing the part played by friction of oil-soaked overalls on the skin of the arms and legs, as a consequent factor of producing oil dermatitis. Since then difficulties have arisen regarding frequent changing and replacing of overalls because of their coupon value and because of increasing laundry difficulties.

Propaganda.—Verbal propaganda is also undertaken by the first-aid and nursing staffs, stressing the above-mentioned factors to all employees who report to the various first-aid rooms with rashes, whether industrial or non-industrial in origin. An example where such propaganda has proved of value has been particularly among inspectresses, who have sitting jobs and have been leaning with arms akimbo on oil-moistened benches, with the result that rashes have appeared on the parts in contact with the oil. These rashes, seen in the early stages, have been treated and the moral pointed out to the girls. Lectures on the factors underlying the prevention of oil dermatitis have been given to apprentices on the principle of 'catching them young.' Other forms of propaganda are by means of posters stressing on workers to report to the nearest first-aid room as soon as they find evi-

dences of a rash. From the numbers of skin cases seen, there must be very few employees in this organization who do not do this. There is no doubt that the official posters dealing with oil dermatitis are not emphatic enough in their appeal and are too verbose to have much value as propaganda. Finally, propaganda measures are intensified during the summer months when rashes of all kinds are commonest.

Measures on the Job. By co-operation with the superintendents and their supervising staffs, the following measures are attended to:

1. Changing the oils as frequently as they become dirty.
2. Adequate cleansing of oil containers as often as necessary.
3. Splash guards on the machines to be adequate.
4. Where required, to see that all workers are supplied with, and encouraged to wear, protective clothing such as oil-proof gloves, aprons and armlets.
5. The oils should be periodically analysed. An outbreak of paraffin oil dermatitis, evidenced by erythema of hands with vesiculation of the webs of the fingers, occurred among workmen engaged in one of the paraffin wash sections. The oil was analysed and was found to be contaminated with cresylic acid. Appropriate steps were then taken to eliminate this.

Incidence of Cases

The measures outlined above have now been established for three years. The number of cases of developed oil dermatitis who have reported for supervision and active treatment every month during this period, have been as follows:

	Jan.	Feb.	Mar.	Apr.	May	June
1941	53	37	44	30	28	22
1942	25	22	43	16	39	20
1943	13	15	12	17	30	23

July	Aug.	Sept.	Oct.	Nov.	Dec.	TOTAL
30	23	27	25	16	18	353
12	12	18	15	16	12	250
11	16	15	18	9	12	191

FIG. 1.—To show lesions of oil acne, folliculitis and furunculosis over lower limbs which were very rarely washed. Note the absence of lesions on hands and forearms which were washed regularly.

FIG. 2.—To show how friction of oil-soaked overalls produces relatively few lesions on the postero-lateral aspects of the leg where friction is not so great.

For security reasons, it is impossible to state the number of workers who are exposed to the hazard of oil dermatitis.

During recent months most of the new cases have been among newly engaged labourers who have to clean out the machines and oil containers and whose mental qualities are such that they are not the best material for propaganda and educative measures. The photographs show a very severe degree of oil dermatitis of the legs of one such labourer with plugging of the pilo-sebaceous follicles with oil, and the evidences of oil acne, folliculitis and furunculosis. He had been cleaning out machines for three months, and although he kept his hands and forearms clean by means of frequent washing and showed no lesions on them he had been very neglectful of the hygiene of his lower limbs, with the results depicted.

Treatment

Most of our cases of developed oil dermatitis are seen in the early stages, and the most efficacious treatment of oil acne consists in washing the areas with soap and water and applying 1 per cent. gentian violet. The diffuse macular and papular rashes and paraffin erythemas are treated with a lotion containing calamine and ichthyol or zinc and ichthyol cream; then when the condition has improved, the patients are again reminded of the protective measures.

In a small proportion of cases, transfer to a job away from oil is deemed a necessary addition to treatment.

From the measures outlined above it will be seen that the prevention and control of oil dermatitis in industrial establishments requires not only the full assistance and co-operation of the staff of the Medical Department but also those of the Labour Department, supervisory technical staffs, chargehands and foremen, and also the laboratory staff. The doctor, the labour manager, the engineer and the chemist, by team work, can all play their part in reducing the incidence of industrial hazards and particularly, as described above, oil dermatitis.

NEW ASPECTS OF NUTRITION

BY

J. R. MARRACK

From the Hale Clinical Laboratory of the London Hospital

The siege of Madrid, which lasted from the end of 1936 to March 1939, gave the first opportunity for the use of the newer knowledge of nutrition in a study of the effects of a fairly uniform inadequate diet on a large population. After the first few months of this period the calories per head per day remained close to 1000 and the total protein about 66 gm.; but the amount of animal protein fell from 15·0 to 4·8 gm. The remarkable feature was that there were never more than about one hundred cases of any of the gross deficiency diseases among a population of about 100,000 (Jiminez Garcia, 1940). Even the manifestations of deficiency of some member of the B group of vitamins were different in different persons. One would get pellagra, with two of the classical three D's, dermatitis, diarrhoea and dementia; another pellagra sine pellagra—digestive disturbances and mental changes, without dermatitis; another would get glossitis; another optic neuritis; and another a paraesthesia. The incidence of paraesthesia and glossitis was twice as high among women as among men, while optic neuritis was twice as common among men as among women. Although the peak of incidence of pellagra, neuritis and optic neuritis occurred in the winter 1937–8, many cases escaped then to become victims in the following winter. It appears that even on a grossly inadequate diet the frank deficiency diseases attack only those who are specially susceptible and may only appear after a long period of deficient diet.

The restrictions of our food supply, at present, have not seriously reduced the amounts of any of the nutrients in our diet, except vitamin C. Scurvy and rickets may persist; but, with this experience of Madrid before us, we must anticipate that other frank deficiency diseases will be confined to people who are abnormal in constitution or food habits. What we must look for are, at most, minor manifestations; and these also, we may expect, will not be distributed uniformly throughout the population, but limited to the more susceptible and will appear only after a long period on a defective diet.

Protein

As far as metabolism is concerned we must regard food proteins as mixtures of the amino-acids into which they are split in digestion. A mixture of amino-acids injected intravenously will keep a human being in nitrogen equilibrium; the amount of amino-acid needed to maintain equilibrium is approximately the same whether the amino-acids are injected as such or derived from protein digested in the alimentary tract (Martin and Thompson, 1943).

Rats will not grow unless supplied with the following ten ' indispensable ' amino-acids:

arginine	methionine
histidine	phenyl alanine
iso-leucine	threonine
leucine	tryptophane
lysine	valine

Adult rats can, however, maintain weight and health when not supplied with lysine and may be able to make histidine, although not sufficiently fast to maintain normal growth.

So far, studies on human requirements of individual amino-acids have been limited to the maintenance of nitrogen equilibrium of adults over short periods. The nitrogen balance becomes negative if the mixture of amino-acids supplied does not include lysine, tryptophane, tyrosine, methionine, leucine, iso-leucine, valine and threonine (Holt *et al.*, 1941). Arginine and phenyl alanine have not been tested. Nitrogen balance is maintained when histidine is omitted from the mixture, but it is possible that histidine may be made slowly and be ' indispensable ' for normal growth and for repair.

Proteins of living cells and of milk and eggs contain more of the indispensable amino-acids, particularly arginine, lysine and histidine, than do the store proteins of cereal seeds. As the greater part of the protein, other than cereal, in our diet is derived from animal sources, the biological value of animal (first class) proteins is higher than that of vegetable (second class) proteins. However, the metabolism of any particular amino-acids taken in the food appears to be affected by the presence of others (Burroughs *et al.*, 1939). This must be taken into account in the assessment of the biological value of diets. The value of a mixture of first- and second-class protein, eaten together, may be higher than the sum of the values of the two taken separately. Thus over half of the protein in four R.A.F. messes was derived from cereals; but Macrea and colleagues (1943) found that the value of this mixed protein was as high as those of liver and kidney proteins.

It is comparatively easy to estimate the minimum amount of mixed protein that is needed to maintain nitrogen equilibrium. However, the optimum intake may be well above the minimum that is needed to maintain equilibrium, with a safety margin added. It is now possible to follow the metabolism of amino-acids given as food. Amino-acids can be synthesized with radio nitrogen in the amino group and heavy hydrogen in the aliphatic chain. These marked elements can be detected in the tissues and excreta. This method has revealed a continual process of exchange, in which amino-acids absorbed from the intestine are incorporated, whole, into the proteins of the tissues or amino groups exchanged between tissue proteins and absorbed amino-acids (Schoenheimer, 1940). This continual process of flux disproves the older view that, in fully grown animals, limited quantities of amino-acids are used for purposes of repair or the formation of special products (such as creatine or insulin) while any surplus is promptly deaminized and metabolized as carbohydrate or fatty acid. It seems probable that the process may be influenced by both the amount and the nature of the amino-acids absorbed, and, therefore, by the quantity and quality of the protein in the diet. In fact a continual process of tissue rejuvenation depends on the character of the food. It would not be surprising if health were related to the rate of this rejuvenation. But there is no satisfactory evidence that any benefit is derived from increasing the protein intake above the U.S.A. standard (Table 1) and two adults, Röse (1934) and Rhyn (1941), claim to have lived for long periods on much smaller amounts.

Normal dogs have a reserve store of protein on which they can draw to replace losses of plasma protein or haemoglobin. This store is lost when the dogs are kept on a diet that contains too little protein to maintain nitrogen equilibrium. It seems probable that human beings have such stores, though smaller in proportion to their body weight. Dogs, with low plasma proteins and reserve stores exhausted, are liable to infections, and conversely infection interferes with the restoration of plasma protein or haemoglobin from food protein (Knutti *et al.*, 1935; Whipple, 1942).

Protein-depleted dogs are extremely susceptible to damage to the liver by chloroform and other poisons. They can be protected against these poisons by the sulphur containing amino-acid, methionine, in amounts comparable with those in a large meal of meat. Choline, which has an effect similar to that of methionine in preventing accumulation of fat in the livers of rats fed on a high fat diet, does not protect, and the other sulphur containing amino-acid, cystine, is less effective than methionine (Whipple, 1942).

Famine oedema is a condition comparable to experimental protein depletion in animals. It appears among the general population only after it has lived for many months on a diet that supplies insufficient calories and is usually preceded by some infectious disease. The oedema is due to reduction of the plasma protein below 5 to 5·5 per cent. In Madrid cases numbered 2 or 3 per month until the end of 1938; then in January 1939, the number shot up to over 100. When a survey was made in a suburb of Madrid in 1941 (Robinson *et al.*, 1942) the average plasma protein was 6·9 gm. per 100 ml., that is, up to the level found among healthy well-fed people in Denver (Trevorrow *et al.*, 1942). Even at this time, the total protein per *man value* was only 66 gm. per day and the animal protein 22 gm. It appears that human beings can not only maintain but even replenish their body protein on these low intakes.

Comparing our present allowances of foodstuffs with the average consumption as found in the Ministry of Labour survey of 1937–8, we find that the average consumption per head per week has fallen as follows: butchers meat 6 oz., fish about 4 oz., eggs 3. Milk consumption, during the months in which the supply is restricted, has risen slightly and considerably during the other months. The total effect is a drop in the average animal protein per head of about 6 gm. to about 33 gm. per day, with a total protein of about 70 gm. This estimate makes no allowance for supplementary meals in private restaurants, British restaurants and canteens, which may well raise the intake of animal protein of some 15 per cent. of the population by over 6 gm.

Owing to unequal distribution of meat and cheese within the family, housewives and children, who do not get meals away from home, may often get considerably less than the amounts recommended in the U.S.A.

When Röse (1934) lived for years on a minimum allowance of protein, he found that minor infections, such as colds (to which he seemed peculiarly liable) caused a negative nitrogen balance. In estimates of protein requirements we must allow a safety margin to cover such losses. Apart from these everyday incidents, more serious infections and injuries may cause great breakdown of body protein. After a simple fracture of tibia and fibula the loss of nitrogen may be as much as 137 gm., equivalent to the protein in nine pounds of muscle (Cuthbertson, 1935–6). Munro and Cuthbertson (1943) state that the protein lost after experimental injuries to animals may come from protein reserves. It is, however, hardly likely that human beings carry 137 gm. of nitrogen as reserve protein, since this is equivalent to about three times the protein in the liver ; a considerable fraction of the loss must have come from muscle. After severe burns the depletion of protein may be much greater, as loss of protein, as such, from the site of injury, is added to loss by breakdown (Taylor *et al.*, 1943). The plasma proteins may fall below the oedema level and healing be delayed. Patients may be unable to eat enough protein to restore the losses and recover only when they are given extra protein by stomach tube and amino-acids by injection.

Even after less severe losses, the rate of replacement of the lost protein will depend, in part, on the

amount and quality of the food. It would take the protein of 30 days of the present food of a normal consumer to replace the lysine of the protein of 9 lb. of body tissue. The rate of rehabilitation will depend on the diet both before injury, since this influences the protein stores, and during convalescence.

Fat

Scarcity of fat was regarded as one of the greatest hardships of the food shortage in Germany and Austria during the last war. I have been told by people who have recently escaped from Holland that their chief complaint was the lack of fat, although the nominal total fat ration in Holland was 5 oz. per week, while the level of the bread and flour ration made it practically impossible to get enough calories. Rats need certain unsaturated fatty acids; but as far as the evidence goes, human beings can do without fats, apart from the few grams needed to assist the absorption of the fat-soluble vitamins. A man has lived for six months on a diet that supplied not more than 5 gm. per day of fat; rats fed on this diet showed typical symptoms of fatty acid deficiency (Brown *et al.*, 1938). Certain fats, butter for example, are important foodstuffs, because they contain fat-soluble vitamins. But the chief value of fats, at the present, is that they are compact forms of fuel and make other foodstuffs more palatable. A slice of bread and butter may supply twice as many calories as the bread alone and appear less filling.

Carbohydrates

Even sugar may have some special function that has, so far, not been recognized. In spite of the evidence, there has always been great reluctance to ascribe increased susceptibility to tuberculosis to a simple shortage of calories as such. Lack of most of the specific nutrients has been blamed at one time or another. The latest study suggests that tuberculous patients do much better if allowed a liberal sugar ration.

In any case, foodstuffs that contain large amounts of carbohydrate must be regarded as indispensable sources of energy and most of them supply other nutrients as well.

Vitamin A

Before the war, butter and eggs were the chief sources of *preformed* vitamin A in our diets. With restrictions of these foodstuffs our daily intake of the *preformed* vitamin is limited to under 1000 international units. This is not necessarily less than the average before the war, for some of the butter then eaten contained very little vitamin A. Now, all margarine, which has taken the place of a large fraction of our butter, contains 450 units per ounce; as much, that is, as in good butter.

Vitamin A is also obtained from the carotene of green vegetables and yellow roots, particularly carrots. Part of the carotene of our food is absorbed and converted in the liver into vitamin A. However, it is uncertain how much of this carotene is absorbed; probably there are wide differences between different individuals in their ability to use carotene. As a convention it is assumed, in reckoning the vitamin A value of diets, that one-third of the carotene is converted into vitamin A.

We must now depend on carotene for a large part of our supply of vitamin A. To reach the low level of 3000 units of vitamin A it is necessary to eat larger helpings of vegetables than were usual; it is hardly possible to reach the U.S.A. standard of 5000 units per day. However, gross deficiencies are less likely to occur now than before the war owing to the more uniform distribution of milk and the addition of vitamins to margarine; but minor degrees of deficiency may not be uncommon.

Vitamin A either forms a part of visual purple or co-operates with visual purple in the perception of light. Vitamin A deficiency not only delays dark adaptation in scotopic (rod) vision, but also very definitely affects photopic (cone) vision. There has been much dispute about the validity of the methods of detecting minor degrees of impairment or delay of dark adaptation. At present the various methods are being compared and there is good reason to hope that a satisfactory method is being evolved.

A fair number of experiments have been made in which the effects of deficiency of vitamin A on dark adaptation have been studied. The rate of development and severity of impairment found have varied widely according to the method used. The estimates of minimum requirements of vitamin A have been based mainly on the results of these experiments. As there have been such wide disagreements, it is quite probable that these estimates are too high or too low. Vitamin A deficiency, if severe enough, undoubtedly leads to night blindness, due to this impairment of dark adaptation, and a large proportion of the population must be getting less than the supposed minimum of 3000 units per day; but difficulties in the black-out cannot all be ascribed to impaired dark adaptation. Many other factors are involved in finding the way in semi-darkness.

An entirely distinct effect of vitamin A deficiency is the keratinization of epithelium which may be seen first in the conjunctiva (xerosis). The surface appears dull, dry and wrinkled; later Bitot's spots appear; these are pearly white patches about 2 mm. in diameter. In the more severe degrees the cornea may ulcerate. Kruse (1940) described certain changes in the conjunctiva—loss of translucency of the deeper layers, as seen with the slit-lamp microscope, and injection of capillaries along lines running from the canthus and fornices to the limbus. But according to later investigations, these changes are not the specific effects of deficiency of any vitamin.

In vitamin A deficiency the skin becomes dry and rough. Round or oval papules may be formed, particularly on the fronts and sides of the thighs and backs and sides of the forearms. These papules are caused by hyperkeratosis of the pilo-sebaceous

follicles. This condition, called phrynodermia, usually clears up on treatment with vitamin A. However, these changes were formerly supposed to be a manifestation of scurvy and in Crandon's experiment (1940), on which he lived on a diet devoid of vitamin C but supplying abundant vitamin A, these skin lesions appeared after 134 days. It seems that the same change may be caused by deficiency of either vitamin A or C and possibly by other deficiencies as well.

Vitamin B_1 (Aneurin)

Aneurin is required in the metabolism of pyruvic acid, an intermediate product in the breakdown of glucose. The requirements vary with the amount of glucose, derived either from carbohydrate or protein, that is metabolized. If the diet contains protein, carbohydrate and fat in customary proportion, it is satisfactory to reckon requirements in terms of the ratio of aneurin to total calories. But if the diets contain abnormally high proportions of either fat or carbohydrate the adequacy should be judged by the ratio of aneurin to the non-fat calories derived from carbohydrate and protein (since a large proportion of the protein is metabolized as carbohydrate). Several studies have been made of the effects of restricted intakes of vitamin B_1. In all these experiments the subjects lost their appetites; they became emotionally unstable, irritable, moody, quarrelsome and depressed; their activities were limited and they failed to co-operate; oedema and cardiac disturbances occurred in some cases. The low intake of 0·1 mgm. per 1000 calories caused, in one case, prostration, mental confusion and paralysis of the quadriceps extensor cruris. This subject was eventually cured after treatment with large doses of aneurin for several months. Williams and her colleagues (1942) found that definite symptoms occurred within 24 weeks when not more than 0·22 mgm. per 1000 calories was supplied; and that evidence of disturbance of carbohydrate metabolism and depletion of stores of aneurin accompanied by fatigue, irritability, poor appetite, insomnia, soreness of muscles, decreased activity and general feeling of poor health, appeared even when aneurin and calorie ratio rose to 0·4 mgm. per 1000. No evidence of deficiency appeared on 0·5 to 0·6 mgm. (167 international units) per 1000 calories. However, Ancel Keys (1943) found no symptoms of deficiency nor evidence of disturbance of the carbohydrate metabolism of normal healthy men who were allowed only 0·23 mgm. per 1000 calories, for 10 to 12 weeks. The subjects of the experiment of Williams were inmates of Rochester State Hospital who had been under treatment for psychiatric abnormalities; they had recovered and were fully capable of exercising a decision in volunteering for this service. They can hardly be regarded as normal and may have needed particularly large amounts of aneurin. Apart from this, requirements may vary. One factor that increases requirements of vitamin B_1 is over-activity of the thyroid.

The amount of aneurin per 1000 non-fat calories supplied by various foodstuffs are: national wheatmeal flour, 0·85 mgm. (285 inter. units); white flour, 0·159 mgm. (53 inter. units); potatoes, 0·16 mgm. (530 inter. units); meat, other than pork, 0·8 mgm. (270 inter. units); pork, 8 mgm. (2,670 inter. units); skim milk, 0·63 mgm. (210 inter. units). The only foodstuff which can now be obtained in appreciable amounts and contains insufficient B_1 to balance its non-fat calories is sugar. The 8-oz. ration per week provides only 130 calories per day, requiring at most 0·065 mgm. (23 inter. units). There is no likelihood of any deficiency of vitamin B_1 at present. But a return to white flour will bring a risk that the more susceptible will suffer from the minor effects of deficiency.

Vitamin B_2 (Riboflavin)

In experiments on animals riboflavin has been found to have a remarkable effect on growth. No experiments have been made on the effects of riboflavin alone, on the growth of children. It was probably the decisive factor in experiments with B complex and contributed to the effects of milk found in the classical experiment of Corry Mann (1926). The most characteristic lesion of riboflavin deficiency is cheilosis—reddening and soreness of the lips along the line of closure and fissures at the angles of the mouth; there may also be a scaly, greasy desquamation in the naso-labial folds, on the alae nasae, in the vestibule of the nose and, occasionally, on the ears and eyelids. Cheilosis has been produced experimentally in subjects who have been kept for some 3 or 4 months on a diet deficient in riboflavin alone, or in B complex. All these cases have been cured by riboflavin and not by nicotinic acid. The amounts of riboflavin needed for cure ranged from 0·025 to 0·075 mgm. per kilogram of body weight per day (Sebrell and Butler, 1939).

Most of the spontaneous cases of cheilosis have been cured by riboflavin. Some cases, however, have not responded to riboflavin and have been cured by nicotinic acid and a few by pyridoxin. Riboflavin and nicotinic acid are both involved at stages of the same process of glucose metabolism. It might therefore be expected that the effects of deficiencies of the two should overlap, and that these effects should be cured by the vitamin which is most deficient in the diet.

Attention has been focussed, during the last few years, on the changes that can be detected by examination of the eyes with the slit-lamp microscope (Sydenstricker, 1940). It appears now that the only change that is specific evidence of riboflavin deficiency is invasion by capillaries of the cornea within a ring around the inner margin of the limbus. Circum-corneal injection, outside the limbus, is not due to riboflavin deficiency; no changes in vascularization that can be distinguished by the naked eye can be regarded as specific evidence of any deficiency.

Both riboflavin and nicotinic acid (in the form of

the amide) are constituents of co-enzymes involved in the dehydration of triose phosphate formed in the metabolism of glucose. It might, therefore, be expected, although there is no direct evidence on the point, that requirements of both these vitamins, like those of aneurin, would vary with the amount of glucose metabolized. In the latest experiment on minimum requirements, subjects lived for 288 days on a basal diet which supplied 0·35 mgm. of riboflavin per 1000 calories. Although no signs of deficiency appeared, there was evidence of depletion of stores of riboflavin. An intake of 0·5 mgm. per 1000 calories was just enough to maintain stores; 0·8 mgm. was more than sufficient.

Nicotinic Acid, Nicotinamide (Niacine)

During the winter of 1937–8 the main foodstuffs in Madrid were flour and rice; the number of cases of pellagra rose to 115 per month in January 1938 (Jimenez Garcia, 1940). Apart from these relatively few cases of gross disease, many suffered from the less typical manifestations, weakness, insomnia, anxiety and loss of memory; these may be regarded as the ' sub-clinical ' evidences of niacine deficiency.

The ' black tongue,' produced when dogs are fed on a pellagra-producing diet, is a necrosis of the floor of the mouth. The resistance of the tissue seems to be reduced and they are attacked by bacteria that normally are saprophytic; the lesions swarm with Vincent's organisms. Similar lesions may occur in dogs deprived of vitamin A. It has been claimed that Vincent's angina and certain forms of stomatitis in men are the result of a lowered resistance due to insufficient nicotinic acid. In some cases treatment with nicotinic acid has been followed by rapid recovery (King, 1943).

It is estimated that a diet that does not supply more than 6·4 mgm. per day may cause pellagra; larger amounts should be allowed to prevent minor effects of deficiency. Estimates based on studies of the excretion of nicotinic acid and derivatives are higher. The standard proposed by Bacharach and Drummond (10 mgm. per day) may be regarded as a minimum.

Our daily allowance of both nicotinic acid and riboflavin was reduced by restriction of our meat supply. But this reduction is now nearly balanced by the increase due to the change from white to wheatmeal flour. In the lower income groups that could not afford much meat the intake of nicotinic acid must have increased, although the average daily intake of the whole population (about 12 mgm. per day) remains low.

A pint of milk contains about 0·8 mgm. of riboflavin. The special allowances of milk for children and for pregnant and nursing women ensure for them a fair daily supply of riboflavin. The milk and solid food of the ordinary adult supplies about 1·2 mgm. per day—barely allows 0·5 mgm. per 1000 calories which may be insufficient to maintain the body's store of riboflavin. However, it has recently been found that beer contains about as much riboflavin as milk and about 8 mgm. of niacine per pint. Half a pint of beer will raise the day's total riboflavin to about 1·6 mgm. which should be enough to maintain the body's stocks and will raise the niacine well above minimum requirements. Tea and meat extracts also add appreciable amounts to the supply of riboflavin.

We have been urged to eat more potatoes. The amounts of nicotinic acid and riboflavin per calorie in potatoes are approximately the same as in wheatmeal flour; so that the daily supply would not be affected by the change from bread to potatoes.

Other Members of the B Group

A large number of cases of glossitis were treated during the siege of Madrid (Jimenez Garcia, 1940). In the more severe cases the tongue was completely raw and very painful. This glossitis was relatively uncommon when pellagra was at its height and reached its peak of incidence about seven months later. Riboflavin and nicotinic acid produced no improvement, but treatment with brewers' yeast was followed by a rapid cure.

The incidence of optic neuritis ran parallel to those of pellagra and paraesthesia. The symptoms were a serious decline in visual acuity; similar cases have been seen in Africa and ascribed to lack of some member of the vitamin B group.

The occurrence of these deficiency diseases due to lack of some factor other than the better known vitamins, warn us that it is far better to eat natural foodstuffs than to depend on deficient foodstuffs supplemented, as is some white flour, with synthetic vitamins.

Vitamin C (Ascorbic Acid)

The citrus fruits and tomatoes that were imported before the war contained enough ascorbic acid to provide everyone in Great Britain with 15 mgm. per day; also these fruits were obtainable in the spring, when supplies from home sources are at their lowest; they are eaten raw, so that there is no loss of ascorbic acid in cooking. Loss of these imports has cut down our supply of ascorbic acid seriously, and greatly increased the likelihood of some manifestations of vitamin C deficiency.

The outstanding contribution to the study of vitamin C deficiency has been Crandon's experiment on himself (1940). He lived for 6 months on a diet supplemented with other vitamins but containing no ascorbic acid. The outstanding symptom was fatigue and weakness which was first noticed after 3 months. He became so weak in the end that he was able to run at seven miles an hour for only sixteen seconds. Papules, similar to those that have been described as manifestation of vitamin A deficiency, appeared after nineteen weeks. No haemorrhages under the skin were seen until twenty-three weeks. The gums were soft and swollen at the end, but never bled. During the thirteenth week of the experiment a piece of muscle was cut out of his back; the wound healed normally. A similar wound was made eleven days before the end

of the experiment, three weeks after signs of frank scurvy had appeared; after ten days it was found that the wound was not healing under the skin, as intercellular substance was not being formed. The wound healed rapidly when ascorbic acid was given.

In this case wound healing was not impaired until after a long period without ascorbic acid. However, the healing of wounds inflicted on guinea-pigs is impaired when they are allowed as much as 2 mgm. of ascorbic acid per day, although 0·5 mgm. per day is enough to prevent frank scurvy. On this restricted intake less intercellular material is formed and the arrangement of fibroblasts is disorganized; if bones are broken the calcification of callus is delayed. Also there is considerable evidence that operation wounds may heal badly, if the subjects have not been provided with enough ascorbic acid, although they may show no evidence of frank scurvy. Recently it has been claimed that healing after extraction of teeth is much more rapid, if the subjects are given large doses of ascorbic acid before the extraction.

In Crandon's experiment no evidence of increased capillary fragility was found at any time. In recent investigations on large numbers of people no correlation has been found between the level of ascorbic acid in the plasma or leucocytes and the capillary fragility (Difs, 1940). Increased capillary fragility cannot be regarded as evidence of ascorbic deficiency, although in actual spontaneous scurvy the fragility does not return to normal unless ascorbic acid, as well as vitamin P, is supplied. We have here an instance in which a secondary factor, extrinsic or intrinsic, is involved in the production of a feature of a deficiency disease. A thoroughly healthy person, whose diet is complete in other respects, may show evidences that are considered characteristic of lack of a food constituent only after very long periods of deprivation or not at all.

The League of Nations estimate of ascorbic acid requirements (30 mgm. per day) is largely based on the experiments of Göthlin (1931), who drew his conclusions from measurements of capillary fragility, although he took bleeding from the gums into account. In the light of the later developments with respect to capillary fragility it appears that this standard should be reconsidered.

The part that nutritional deficiencies play in the etiology of gingivo-stomatitis is disputed. The mouth, however, does not differ from other parts of the body; inflammation and ulceration may be due to many causes. A bacillus or virus may be sufficiently virulent to attack a healthy mouth or may only gain a footing when the mucous membrane is damaged by lack of one of several dietary factors. The gums almost always swell and bleed in true scurvy and improve rapidly when ascorbic acid is given. It is reasonable to suppose that, in some instances, gingivitis is due to vitamin C deficiency. It has been found that some cases improve rapidly when ascorbic acid is given while others may be better treated with nicotinic acid.

As the war has cut off one of our main sources of ascorbic acid, we have to pay special attention to the remaining sources. Potatoes are our mainstay as large amounts of potatoes are eaten regularly. But potatoes contain on the average about 8 mgm. per 100 gm., so that the amount that they supply per head per day is about 12 mgm., which is not enough. As potatoes are kept, the amount of ascorbic acid that they contain falls. In spring and early summer they may supply only 3 or 4 mgm. per day. Other vegetables, which contain ascorbic acid, are scarce at the same time; the best use must be made of the limited supply. Vegetable cells contain an enzyme, ascorbic acid oxidase. When the cells are damaged by bruising or heating, this enzyme is set free and attacks the ascorbic acid. Vegetables should be heated rapidly in order to destroy the enzyme before a large part of the ascorbic acid is lost. When vegetables are heated rapidly to over 80° C. and cooked for the minimum time the proportion of ascorbic acid destroyed is small, but as much as three-quarters may be dissolved out into the cooking water. Uncooked cabbage for example, may contain 70 mgm. per 100 gm.; if it is put into the minimum volume of boiling water, heated up rapidly and cooked for 20 minutes the solid may contain 30 mgm. per 100 gm. and the water some 90 per cent. of the remainder. If vegetables are kept hot for more than half an hour after cooking the further losses of ascorbic acid may be considerable (e.g. one-half in two hours and three-quarters in five). The obvious way of avoiding these losses is to eat green vegetables raw. There are, however, two objections. The amounts of green vegetable that people will eat raw are relatively small although they look big. The normal salad vegetable, lettuce, contains only about 10 mgm. of ascorbic acid per 100 gm.; a moderate sized lettuce weighs about 50 gm. Helpings of salad do not usually exceed 20 gm., so that even when the vegetables that contain larger amounts are used, the total is about 14 mgm. In the second place, green vegetables are needed to supply carotene. Carotene is not affected by cooking and is less well absorbed from raw food. If cooked vegetables are not eaten the amount of carotene obtained will be insufficient. Although the supply of vitamin C may well be raised by the use of raw vegetables, abundant cooked vegetables should be eaten as well.

Vitamin P

There seems now to be no doubt that capillary resistance is maintained by a vitamin P, of which the chemical nature is not known. It is found in fruits and vegetables, but the distribution does not run parallel to that of ascorbic acid; unlike ascorbic acid it is heat stable.

Calcium, Iron and Phytic Acid

National wheatmeal flour contains about 140 mgm. of phytic acid in 100 gm. as compared with 15 mgm. in white flour. This phytic acid forms insoluble compounds with calcium and iron; McCance and

Widdowson (1942) and Krebs and Mellanby (1943), have shown that it interferes with the absorption of these two elements. In view of the experience of peoples and groups who have lived all their lives on whole cereals a serious deficiency of calcium and iron seems unlikely. However, it has been reported that the incidence and severity of rickets in Eire has increased since flour of a very high degree of extraction (over 90 per cent.) has been in use. To avoid the risk in Britain, 7 oz. of precipitated chalk are now added to the 280-lb. sack of flour.

Iron requirements remain something of a mystery. It was at one time supposed that iron in organic combination, as in haemoglobin, was not available, but this belief has been abandoned. Absorption of iron from the food seems to be regulated by requirements. Very little iron is excreted; iron derived from the breakdown of haemoglobin can be used again. The requirements of men should be negligible; the average loss in menstruation is only 23 mgm. per month, so that a few milligrams per day should suffice for women.

There is no evidence that an increase of the iron in the food by a few milligrams, *without* a change of other constituents of the diet, has any effect on anaemia. Haemoglobin levels may be affected by other nutrients of the diet besides iron; it should not be forgotten that haemoglobin is a protein that contains a large amount of histidine. It is possible that the increase of haemoglobin levels that follows large doses of iron may be comparable with the increased production of plasma protein after doses of iron citrate, found by Pommerenke (1936); low plasma protein cannot be ascribed to iron deficiency.

After nearly two years of wheatmeal bread there is no evidence that Britain is becoming anaemic.

Iodine

There are areas in Great Britain in which the concentration of iodine in the water supply is low, and the incidence of goitre is high in these areas. With the scarcity of fish, the risk of goitre is considerably increased. The minute amount of iodine required (about 0·014 mgm. per day) can be supplied by the addition of an iodide to table salt.

Canteens and British Restaurants

The large-scale provision of *table d'hôte* meals in canteens and British Restaurants gives an opportunity to make good the probable deficiencies in war-time diets. One of these deficiencies, that of animal protein, is met by the extra allowances of meat, cheese and dried milk. Our present food policy is fundamentally the breadstuffs policy of the last war. Bread and flour are cheap and unrationed; they can be bought in unlimited amounts to supply calories. However, people are not guided in their choice of food by requirements, but by custom and appetite. If they can get less of the foodstuffs—butter, jam, meat—which they eat with bread, they are liable to eat less bread, not more, and go short of calories. Canteen and restaurant meals should therefore provide abundant calories. Also, as the main meal of the day, at which vegetables are eaten, they should make good the supply of vitamins C and A with vegetables. In practice it is found that a meal with abundant vegetables that provides over 1000 calories is too bulky for most people to eat before their afternoon's work. Without 1000 calories at the main meal it is difficult to bring the day's total up to requirements. Apart from ultimate loss of weight and health, recent work suggests that the people become irritable when they do not get enough calories—this startling discovery was anticipated in the proverb ' a hungry man is an angry man '.

Another aspect of this fuel problem is the relation of efficiency to the level of blood sugar. Haggard and Greenberg (1935) claim that physical efficiency (that is, the ratio of work done to total energy expanded) and efficiency in the sense of rate and quality of work are impaired when the blood sugar falls. After a breakfast of carbohydrate the blood sugar rises to a peak in about three-quarters of an hour and may then fall to about 70 mgm. per 100 c.c. (Conn, 1936). After a breakfast consisting largely of meat the blood sugar remains steady. It is suggested that people now suffer more from low blood sugar and a consequent sinking feeling in the middle of the morning because they eat less meat for breakfast. But I am sceptical about these meat breakfasts. Few workers can afford and few housewives have time to cook a beef-steak breakfast. The change that rationing has brought is that, with less bacon and butter, less fat is eaten; the amount of other more bulky and less appetising foodstuffs eaten is not enough to make up the deficiency of calories.

The remedy both for the fall in blood sugar and for the difficulty of supplying enough calories at the midday meal is to provide a mid-morning snack.

Standards

The standard proposed by the Food and Nutrition Board of the U.S.A. (Table 1) was adopted by the Conference on Food and Agriculture at Hot Springs as an ultimate goal; it is the standard that is now generally used. When it is attained, there should be no danger of any possibility of impairment of health, growth or efficiency for lack of any nutrient.

Two comments may be made. The allowance of vitamin A may be reconsidered in the light of further studies of impairment of dark adaptation. The allowance of ascorbic acid is sufficient to maintain the ascorbic acid in the plasma above 0·6 mgm. per 100 c.c. The evidence that any benefit is derived from an increase above the 30 mgm. proposed by the League of Nations is unsatisfactory; but the higher allowance is advisable when the object is to guarantee that it should be adequate under all conditions.

Vitamin Supplements

The amounts of all the vitamins, other than B_1, in the average diet in Great Britain to-day is less

TABLE 1

DAILY INTAKE OF NUTRIENTS RECOMMENDED BY THE FOOD AND NUTRITION BOARD, NATIONAL RESEARCH COUNCIL, U.S.A.

	Calories	Protein, gm.	Calcium, gm.	Iron, mgm.	Vit. A, Int. Units[1]	Vit. B_1, mgm.	Ribo-flavin, mgm.	Niacine, mgm.	Ascorbic acid, mgm.	Vit. D, Int. Units
MAN (70 Kgm.)										
Sedentary	2500	70	0·8	12	5000	1·5	2·2	15	75	
Moderately active ..	3000					1·8	2·7	18		
Very active	4500					2·3	3·3	23		
MAN (56 Kgm.)										
Sedentary	2100	60	0·8	12	5000	1·2	1·8	12	70	
Moderately active ..	2500					1·5	2·2	15		
Very active	3000					1·8	2·7	18		
Pregnant (latter half)	2500	85	1·5	15	6000	1·8	2·5	18	100	400–800
Nursing	3000	100	2·0	15	8000	2·3	3·0	23	150	400–800
CHILDREN up to 12 years[2]										
Under 1 year ..	100	3–4 Kgm.	1·0	6	1500	0·4	0·6	4	30	400–800
1–3 years	1200	40	1·0	7	2000	0·6	0·9	6	35	
4–6 ,, ...	1600	50	1·0	8	2500	0·8	1·2	8	50	
7–9 ,, ...	2000	60	1·0	10	3500	1·0	1·5	10	60	
10–12 ,, ...	2500	70	1·2	12	4500	1·2	1·8	12	75	
CHILDREN over 12 years[2]										
Girls: 13–15 years ..	2800	80	1·3	15	5000	1·4	2·0	14	80	
16–20 ,, ..	2400	75	1·0	15	5000	1·2	1·8	12	80	
Boys: 13–15 ,, ..	3200	85	1·4	15	5000	1·6	2·4	16	90	
16–20 ,, ..	3800	100	1·4	15	6000	2·0	3·0	20	100	

[1] May be less if provided as *preformed* vitamin A; more if as carotene.
[2] Allowances based on needs for middle year of each period.
Note the large amounts of protein recommended for children and for pregnant and nursing women.

than the amounts recommended in Table 1. It might be expected that some benefits would follow the administration of vitamins over long periods. On the whole, the results of recent experiments have been disappointing. For example, Jenkins and Yudkin (1943) have reported the results of an experiment in which vitamins A, B_1, C and D were given to elementary school children for a year. No difference between these children and a control group in physical capacity, gain in height, weight, haemoglobin, dark adaptation, educational attainment or intelligence, was noticed. There was, however, a slight reduction in the incidence and duration of colds in the supplemented group. The Ministry of Health in collaboration with local health authorities carried out an agreement on a very large scale; this has been reported briefly (Bransby *et al.*, 1944). Vitamins A, B_1, C, D, riboflavin and nicotinic acid were given. In the studies on children, which were very thorough, no statistically significant effect was produced on rate of growth, nutritional status, muscular strength, condition of teeth and gums or absence from school on account of illness. However, Kohn, Milligan and Wilkinson (1943) selected the boys in one area who showed evidence of deficiency of vitamin A as judged by impairment of dark adaptation (A group), of severe vitamin C deficiency (C group) or both (A and C group), who were receiving no supplements, and compared these with boys in this area receiving supplements. They found that the weight increase in 37 weeks was less in the A group, the endurance less in the C and AC groups. This suggests that the average supply of the vitamins concerned in our food is enough for the average, but that a fraction of the children get less than they need.

In this same experiment rather less satisfactory studies were made on zinc smelters. No significant effect was found on weight, haemoglobin, blood pressure, absence from illness or output of work.

On the other hand, Harper and others (1943) reported that supplements of vitamin A, D and C to cadets improved vital capacity, breath-holding time, endurance and reduced susceptibility to minor ailments. Frankau (1943) also found that supplements of 40 mgm. of nicotinamide per day increased efficiency in carrying out fairly severe tests involving physical effort and co-ordination.

It is obvious that supplements of a nutrient will not benefit those who are already receiving enough of it. There may, however, be a few individuals in any group who are not getting as much as they need. These will benefit from supplements, but will be submerged in a statistical analysis of the whole group. The large-scale studies, with sausage-machine methods of statistical analysis, should be supplemented by thorough investigations of small groups.

Summary

1. Experience during the siege of Madrid suggests that the more obvious deficiency diseases appear only among the specially susceptible.

2. Certain aspects of the functions of nutrients and effects of deficiency are considered.

3. The protein supply may have an important influence on the rate of recovery from injuries and infections.

4. The vitamins most likely to be deficient in our present diets are A and C. Abundant green vegetables should be eaten to ensure the supply of both of these and care should be taken in cooking in order to prevent destruction of vitamin C.

5. National wheatmeal bread supplies an important fraction of our riboflavin and nicotinic acid; the phytic acid which it contains may interfere with the absorption of calcium and iron.

6. The composition of communal meals and the value of vitamin supplements are discussed.

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MEDICAL SERVICE IN INDUSTRY IN THE U.S.S.R.*

BY

AUGUST LETAVET

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Many of the largest war factories in Russia have had to be transferred to remote districts, where proper arrangements had to be made for the accommodation of large numbers of workers in conditions such as to promote maximum output and reduce the incidence of disease of all kinds, including special industrial hazards. According to G. A. Mitarev 'there are three main problems of health protection in war-time; firstly, to establish hospitals so as to secure the efficient rehabilitation of men of the Red Army; secondly, to combat epidemics; and, thirdly, to provise good medico-sanitary services for war factory workers.'

Organization of Medico-Sanitary Services in War Factories

A 'Medico-Sanitary Administration' (M.S.A.) was set up in each war factory to co-ordinate the medical services available for the workers, and sometimes also for their families. This Administration usually comprised a 'Polyclinic' with specialist departments, ambulance posts staffed by doctors or nurses in the larger shops, and pathological laboratories. Special hospitals were provided for the larger factories if local hospital facilities were insufficient. All factories came under the control of the State Industrial Sanitary (S.I.S.) Inspection Administration. The work of the M.S.A. includes hospital treatment, first aid, domiciliary visits, and factory inspection. Full records are kept of sickness and accidents, preventive measures applied, and health education of workers carried out. The M.S.A. co-operates closely with trade unions and social workers, who meet on joint committees.

Industrial Hygiene Research Institutions

There are now five special institutions for research in industrial medicine in the Soviet Union, viz.:

1. The Obukh Central Institute of Labour Hygiene and Occupational Diseases, Moscow.
2. The Ukrainian Institute of Hygiene, now working at Novosibirsk.
3. The Institute of Labour Hygiene and Occupational Diseases, Leningrad.
4. The Urals Institute of Labour Hygiene, Sverdlovsk.
5. The Institute of Labour Hygiene and Occupational Diseases, Gorky.

The first of these, and the largest, was founded in Moscow in 1923 by V. A. Obukh, then head of the Public Health Board for Moscow and district. The present Director is Professor Z. B. Smelyansky. The Institute includes a clinic for industrial diseases, in charge of Professor S. M. Genkin, with accommodation for 200 patients, and with biochemical, pathological and other laboratories. The large Hygiene Department (under control of the present writer) has laboratories for the study of industrial physiology and toxicology, dust hazards and ventilation; as well as meteorological and physico-chemical laboratories. The Ukrainian and the Urals Institutes deal mainly with coal and iron industries, and the Gorky Institute with the chemical industries. In spite of the blockade, the Leningrad Institute has never ceased to carry on research work, as well as dealing with special local problems such as the hygiene of bomb shelters and the prophylaxis of frost-bite.

Ventilation Problems

Black-out arrangements in factories sometimes led to overheating, especially during the hot summer weather, while removal of noxious fumes became more difficult. Shops were fitted with venetian blinds, labyrinths, shields, etc., while in the 'heat shops' (open-hearth furnaces, rolling mills, forging and casting shops, etc.) 'air showers' were installed. Loss of sodium chloride in the sweat was corrected by provision of unlimited supplies of soda-water containing 0·3–0·5 per cent. of table salt.

Industrial Toxicology

The Obukh Institute has issued leaflets dealing with prevention of industrial poisoning, and M.S.A. personnel have been instructed in risks of materials such as T.N.T. Routine medical examination of all workers in T.N.T. is compulsory, and especially susceptible persons are transferred to other work. The Obukh Institute has devised methods of dealing with the risk of electric welding in tanks and other confined spaces. This is liable to set up asthma and bronchitis from inhalation of dust and toxic gases. Legislation was introduced in 1942 to reduce toxic hazards by hermetical enclosure of

* Condensed by D. C. Norris from a translation kindly lent by the Anglo-Soviet Journal.

machines, efficient transportation of dust-forming substances and by application of wet methods of boring, crushing, grinding, and polishing. Regulations control the maximum permissible concentration of toxic substances in the air of factories.

Supply of Vitamin C

Where large numbers of workers were moved to new localities there was often great difficulty in providing adequate amounts of fresh vegetables. Deficiency of vitamin C was made up by giving extracts of Ural pine or fir needles, or infusions of Siberian pine or larch, containing often as much as 200–300 mg. of ascorbic acid per 100 gm. of pine needles.

Health of Women Workers

There has been a great increase in the number of women factory workers. They showed, generally speaking, a lower incidence of accidents and of skin infections—probably owing to their greater attention to safety regulations and better personal hygiene than men. Excluding absence for pregnancy, or to attend to sick children, they showed also a lower sickness rate than men. On the other hand, they were slightly more susceptible to industrial poisoning, especially by T.N.T.. Special medical services for women have been set up in many factories, including gynaecological and antenatal clinics, day nurseries and ' Feminine hygiene rooms ' in some of the larger plants.

Under the stress of war the aim of Soviet industrial hygiene has been to reduce occupational risks and prevent sickness among factory workers, and to conduct experimental and theoretical research on various problems of industrial hygiene and toxicology, and thus to contribute to the advance of science as a whole and to the effort of the Soviet people to defend their country and expel the Hitlerite invaders.

HEATING AND VENTILATION:

REQUIREMENTS AND METHODS

Addendum to Paper by T. BEDFORD. (This Journal, Vol. I, No. 1, p. 31)

On p. 35 reference was made to the scale of *equivalent warmth*, derived by Bedford (1936), by which the combined effects of the four factors which make up the thermal environment can be expressed in a single figure. The equivalent warmth was defined as the temperature of a uniform enclosure, with air and surroundings at the same temperature, and with the air still and saturated with water vapour, which would produce a sensation of warmth equal to that evoked by the combination of radiation and air temperature, velocity and humidity in question.

Through an oversight no mention was made of two other developments concerning the concept of equivalent warmth. Dufton (1936) proposed that the scale should be referred to semi-saturated and not saturated air, mainly on the ground that under extreme humidity conditions there is a difference between sensations of warmth and of comfort. This view was taken later by the Joint Committee (of the Medical Research Council and the Department of Scientific and Industrial Research) on Research in Heating and Ventilation, which provisionally defined the equivalent warmth of an environment as ' that temperature of a uniform enclosure in which, in semi-saturated air, equal warmth would be experienced ' (Douglas, 1938).

In his 1936 paper, Dufton gave a chart which, in the absence of appreciable radiation, enables equivalent warmth to be determined for various temperatures, humidities and degrees of air movement.

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THE NURSE IN INDUSTRY

The industrial nursing service is an essential part of an industrial medical service, and its efficiency determines in considerable measure the success of medical supervision in factories and other sections of industry. That industrial nursing is a growing branch of the profession is seen by the fact that some 9000 nurses are to-day employed in industry —about three or four times as many as in 1939. The contribution of A. J. Amor and Clare Sykes in this issue is therefore timely, emphasizing as it does the need for improving standards not only by better selection but by more adequate training and education of those nurses who chose industry as a career. It defines the widening scope of the industrial nurse, who in the past has often been considered less fortunate than her colleague employed in other branches of nursing. The authors show that the need for nursing services has developed rapidly and urgently since the war started, and they base their observations on work at the Ministry of Supply in their respective capacities as Chief Medical Officer and Chief Nursing Officer.

When we consider the field which has to be covered in any reasonable course of training for industrial nurses we may regret that such comprehensive training has not also been available for doctors. The more we look into this question of education the more complex does it appear, but with the new emphasis on social medicine and the recognition of the importance of industrial medicine by the Universities many of the difficulties should disappear in the post-war world. While the importance of a comprehensive academic background is recognized the writers of the article well point out that the fundamental education of the industrial nurse must take place within the factory, the ship-yard, the dock and the mine, and that those who are to teach must be those with practical experience of industry. The difficulty of obtaining teachers is recognized. Dr. Amor and Miss Sykes believe, however, that those who have done most to establish standards of practice in a new field are those who are most concerned with the education of its future practitioners. If the broad direction of training is left in their hands this will ensure that the practical requirements and problems of an industrial medical department are kept to the fore. With the development later of Departments of Industrial Medicine at the Universities part of the problem may be solved, but these departments themselves must be elastic enough, as the recent report by the Social and Preventive Medicine Committee of the Royal College of Physicians suggests, to incorporate among their teachers those with practical experience of industry. What this report says of the medical student applies equally to the nurse. She is not expected to become an expert in occupational diseases. It is much more important that in addition to technical skill in nursing she should acquire knowledge and understanding of the social problems relating to industry and be able to recognize, as part of a team with her medical officer, 'the mental and physical response of the worker to fatigue, overwork, monotony, unsuitable hours or type of employment.' She needs to know something too of home conditions, particularly in these days of imported labour and billeting difficulties. And all this must be backed up by a knowledge of processes and occupations in the factory. When a girl tells her that she works on a capstan or a drilling machine, or a man that he is a moulder or a stamper, she must know exactly what that means. These things tend all the time to make this type of nursing attractive, and there is much personal satisfaction in work which maintains a man at his job and prevents, in considerable measure, the hardships which result from interrupted employment.

We fully recognize the pioneer work of the Royal College of Nursing. But much of that work would have been ineffective without the co-operation of a small number of industrial medical officers, mainly in London, who from the start have devoted themselves to the development of their specialty. The training of industrial nurses is primarily the responsibility of the industrial physician, and the experienced nurse herself must also play her part in training her junior; but the major burden must be borne by the medical profession. In so far as it has been able the Association of Industrial Medical Officers, collaborating with the Royal College of Nursing and various Universities throughout the country, has organized refresher week-end courses for nurses already engaged in industry. That there is a great demand for such training is obvious. But something further is needed—namely, short intensive or even prolonged training of the new entrant before appointment. The College of Nursing, as Dr. Amor and Miss Sykes point out, has led the way. In 1934, in collaboration with the University of London they inaugurated a full-time course of one year's duration. Later, part-time, correspondence and other courses were also provided. The University of Birmingham, in conjunction with the Birmingham Accident Hospital, has also entered the field, and it will be interesting to watch this new venture, which, because of University backing, should do much to raise the status of industrial nursing.

A final word of warning is necessary. All nurses in industry cannot expect to occupy senior and responsible posts from the beginning. They must work up from the lowlier positions, many of them apparently dull and mainly to do with routine treatment of minor accidents and illnesses. In the interests of the working community these humbler jobs must always be done, and many nurses find a

true vocation in doing them. But the chance of promotion for the industrial nurse was never greater than it is now. The facilities for education and training are becoming better known and more widely available, and in time the highest posts will be open to all who are fitted to fill them.

WOUND INFECTION IN INDUSTRY

The treatment of minor injuries occurring at the place of work is an important part of the work of the industrial medical officer and his nurses. The higher the standard of treatment in the factory the less is the risk of sepsis, with its consequent absence from work and increase in permanent disablement. The treatment of major wounds is largely the responsibility of the hospitals, and with that side of the problem we are not concerned here. But the millions of minor injuries that occur annually are injuries that cause no loss of time—and within industry itself present a challenge to the medical officer. For many years he has worked alone in this field. He has frequently improved conditions because his standards are obviously far beyond those of the first-aid worker who dabbles in the subject—often as a hobby but so often to the detriment of the injured man. But in this matter of wound treatment he needs help, particularly from the bacteriologist; and he needs advice from his surgical colleagues, if only from one point of view —what to leave alone.

When we consider that even to-day most workpeople have no nurses and doctors to superintend the treatment of accidents at work the problem becomes serious in terms of manpower and production. S. A. Henry, in his recent Milroy Lectures,[1] tells us that the actual number of reportable factory accidents in which sepsis supervened increased from approximately 21½ thousand in 1939 to 22½ thousand in 1942; the large increase in the numbers employed reduced the percentage figure from 11 to 10·3. It would be interesting to know the criteria upon which the diagnosis of 'sepsis' is made. Because of the apparent absence of definition this figure is unlikely to represent the true state of affairs, and it is an interesting fact that there is no obligation upon the employer specifically to report such cases. In many instances the diagnosis of 'sepsis' is left to the first-aid worker and the untrained nurse—and often to a welfare supervisor or an office clerk—who may be the main contact on such matters with the firm's insurance company or the Factory Department of the Ministry of Labour. But even so, it is one index of the incidence of wound infection in industry, an incidence which is probably higher than published figures suggest. It is to be hoped that more accurate figures will one day be available, not only from factories but from other industries such as mining, docks, construction, ship-yards, and the various transport services. But until we can get the facts we can do little more than guess at a figure.

Those who are engaged in industrial medicine therefore welcome the decision of the Medical Research Council to set up a bacteriological unit at the Birmingham Accident Hospital. Here the whole question of wound infection as it affects industry will be closely studied in conjunction with clinicians skilled in accident treatment, with industrial doctors and with nurses. In this issue we publish from the unit one of a series of studies on the problem by Gissane, Miles and Williams. It refers specially to the design of dressing stations. They tell us that many wounds are already septic when first seen in the factory surgery, and that a proportion of open wounds become septic during treatment. We would observe that, just because so many wounds are not seen by the nurses or the doctor in industry until they are in fact septic, health education and propaganda on the prevention of wound infection become a matter of the first importance. The difficulties of educating the great masses of workers are not always appreciated, nor, indeed, is it the responsibility of laboratory workers or hospitals. But its significance in this particular problem is clear, and the results of a long-term research such as the Medical Research Council has inaugurated, affecting in one way or another the majority of our working population, must eventually be expressed in plain language. The help of such a body as the Central Council for Health Education might be enlisted for this. Simple rules must be laid down for first treatment, not only that to be carried out by 'the responsible person trained in first-aid treatment'—to quote section 45 of the Factories Act—but that which becomes the responsibility of the nurse and of the industrial doctor himself.

It is interesting to note that 'silent infection,' which may be present in up to 40 per cent. of the wounds treated at the factory, not only delays healing but also forms a reservoir of organisms capable of infecting clean wounds treated in the same surgery. The important point is made that an aseptic technique must therefore be designed to prevent cross-infection from these wounds already septic or 'silently' infected. The authors have wisely attempted to set their own house in order at the hospital and by doing this have anticipated criticism. Indeed the hospital problem, as the Medical Research Council has pointed out in a recent memorandum,[2] is in itself one which needs looking into. This report showed that, while pyogenic organisms are found in only a small proportion of open wounds examined on admission to hospital (the figures have been 5–6 per cent. in the present war compared with 15–20 per cent. in the last war), the proportion of infected wounds may exceed 50 per cent. after a week's stay in hospital and increases with further residence. These findings have been confirmed in industry.

The difficulty of altering present conditions and of instituting aseptic technique is recognized. But

[1] *Lancet*, Dec. 11, 1943.

[2] War Memorandum, No. 6.

the first stage in this direction is the proper planning and lay-out of the industrial dressing station. Without this a suitable technique cannot be established nor infection controlled. The dressing station staff in industry will not at first be prepared to spend time in improvements the value of which only a long-term application will reveal, and Gissane and his colleagues recognize the fact that the works ambulance room is also used for other purposes than wound dressings. The main recommendations, however, must be carefully considered by all those who have the personal responsibility for large numbers of daily dressings.

Another contribution of much interest to industrial medical officers is that of Colebrook, Gibson and Todd on the first-aid treatment of burns. In certain of our industries—for example, the casting of metal—burns are only too common, and the wastage of man-hours from this cause is well recognized. But most burns in industry are not serious enough to need hospital treatment; yet no matter how trivial, every burn is a source of infection. The authors maintain that it is important to distinguish clearly between temporary treatment at the scene of the accident, or first aid, and the further treatment carried out by a doctor or nurse, which they term 'plenary' treatment to convey the idea of completeness. The treatment of burns is intimately bound up with the problems of wound infection, and the main conclusion which Colebrook comes to is that avoidance of infection by the haemolytic streptococcus should dominate first-aid policy for all but very severe burns, where general measures often have to take precedence over local treatment. A simple first-aid measure is recommended—namely, the local use of a water-soluble cream containing 1 per cent. of cetyl trimethyl ammonium bromide and 3 per cent. sulphanilamide. Part of the experimental work has been done within the factory dressing station as well as the hospital, and the arguments in favour of giving an extended clinical trial to this new method are convincing.

The war has underlined the great need for collaboration between the clinician and the bacteriologist in tackling the ever-present problem of wound infection. The two must study the industrial problem at the place where it arises—in the factory, in the mill, in the coalmine, in the workshop. The challenge from industry to medicine must be met, and in industry, at least, the doctor should find a full appreciation of his difficulties as a technician; he may even learn from the industrial technician how best to solve problems which at a superficial glance may seem to be medical only.

ABSTRACTS

Health of the Factory Worker in War-time. Milroy Lectures. HENRY, S. A. *Lancet*, December 11, 1943, p. 721 ; December 18, 1943, p. 762.

There are over a quarter of a million factories in this country, employing some 7½ million persons. The term factory includes premises for manual labour such as a dry dock for ship-building and repairing, a factory line or siding, or a gas-holder. For every case of industrial disease or gassing there are over 50 cases of tuberculosis, and over 500 cases of infectious disease. Non-occupational illness is therefore a far greater factor in absenteeism than occupational disease. Information regarding specific industrial disease is by means of statutory notification to the Factory Department. The role of factory inspectors in recent years has tended to become more that of the welcome adviser to employer and employed, with sanctions well in the background. The number of accidents from all causes has shown a progressive increase from nearly 193½ thousand in 1939 to nearly 312½ thousand in 1942; but the number of persons employed has also increased. The number of gassing accidents increased greatly in 1940 and 1941, but the mortality rate fell from 9·6 per cent. before the war to 4·6 per cent. in 1941. Nitrous fumes have been responsible for much of the increase.

Certain substances when absorbed in sufficient quantity cause an immediate effect classified as an accident; but when absorbed in smaller quantities over a period may cause a chronic effect with a different clinical picture. Examples are poisoning by tetrachlorethane, causing toxic jaundice; diethylene dioxide or dioxan, causing hæmorrhagic nephritis; and during this war methyl bromide, tricresyl phosphate, and triphenyl phosphate. There has been a decided increase during the war in the number of cases of acute trichlorethylene poisoning. Benzene (benzol) may cause acute gassing, and also a more chronic condition with a totally different picture.

It would be interesting to know what percentage of doctors are aware that notification of any industrial disease is required, let alone the names of the 14 diseases on the list—namely, lead, phosphorous and arsenical poisoning and anthrax from 1896; mercurial poisoning from 1899; toxic jaundice from 1916; epitheliomatous and chrome ulceration from 1920; carbon bisulphide, aniline and chronic benzene poisoning from 1925; manganese poisoning from 1936; compressed air illness from 1939, and toxic anaemia from 1942. The total number of all cases notified was some 550 in 1941.

Voluntary notification of occupational dermatitis has been encouraged by the Factory Department for some years, and the cases notified seem to constitute a fair sample of those arising annually in factories. New substances and new workers may cause an increase in cases. When celery canning was first introduced celery dermatitis first appeared. New timbers have caused dermatitis in wood-working shops where previously it had been absent. Engineering accounts for 23 per cent. of cases, but if metal work, welding, plating, and polishing are added the percentage reaches 30·5. Contact with explosives such as T.N.T. and tetryl are responsible for 29·5 per cent. of the total number of cases since 1939. Recently an advisory panel on dermatitis in industry has been appointed to advise the Ministry of Labour.

D. S.

Weight Lifting. TUGMAN, R.E. *Indust. Welfare*, 1943. November–December, p. 169.

The loads which some workers are called upon to lift may be very great. The stowers in the jute and flax industry carry bales of jute weighing 400 lb., but considerable reductions in many loads have been made in recent years, e.g. the 280-lb. sack of flour has been generally replaced by the 140-lb. sack. The lifting of weights is very different from carrying them, and raising a load from the ground is particularly onerous. The principle to be adopted is to use the leg muscles, not the abdominal muscles. When lifting from the ground the feet should be kept close together, the knees bent and the back straight. The load is firmly gripped and the knees straightened, the strong leg muscles doing all the work, whilst there is very little strain on the straight back. The effects of excessive weight lifting are cumulative, and women and young persons should be particularly watched. They should not be allowed to lift weights above breast level, and should learn to throw as little strain as possible on the abdominal muscles. The avoidance of lifting accidents should be a matter of pride, and the occurrence of such an accident should be considered a slur on the department in which it occurs.

The author maintains that weight lifting very seldom induces hernia.

H. M. V.

Am I injuring my Eyes? GRANGE, R. *Indust. Welfare*, 1943. November–December, p. 174.

When welding, the infra-red rays of the visible glare may cause corneal ulcers and cataract, whilst the ultra-violet rays may cause conjunctivitis. It is important that different types of protective glass be used for different types of welding. For gas welding, which is mostly by means of oxy-acetylene, the best protection is given by B.S.S. 679 glass. This protects against glare, infra-red and ultra-violet. It is made in three tints, A, B and C, A or B tint being preferable for light welding of iron or steel, and tint C for burning operations. Blue glass should not be used, for it does not protect against ultra-violet or infra-red rays. For electric arc welding tints C, D and E (of B.S.S. 679) should be used for light, medium and heavy welding respectively. The welder's mate needs a different form of protection. He is working as near the arc as the welder himself, but cannot be given a dark welding glass as he has to see clearly in order to hold the plate in the correct position. It is best for him to have goggles fitted with the nearly colourless Infrex glass, which absorbs the infra-red rays. The mate should turn his head away when the welder strikes his arc.

During the grinding of heavy castings the operator should wear a hood with goggles and respirator attached in one piece. All goggles should be fitted with safety glass, either laminated or hardened and toughened.

H. M. V.

Creosote Burns. JONAS, ADOLPH D. *J. Industr. Hyg.*, 1943. Vol. 25, p. 418.

The construction of barracks and temporary housing structures calls for the increasing use of wood preserved with creosote. The present observations on the effects of creosote were made during the construction of a U.S. Navy camp, and 450 patients, or a sixth of the workers, had to be treated for creosote burns. The pieces of timber were dipped into creosote tanks, and after drying for several days were sawn into short blocks by the carpenters. This particular process was the chief cause of the burns, as the sawing caused the scattering of fine sawdust saturated with creosote, which burnt the unprotected skin. Workmen with a fair skin and light hair were particularly affected, but coloured workers were scarcely affected at all. Seventy per cent. of the cases were mild, showing erythema of the face, followed,

after a few days, by some pigmentation. In the 30 per cent. of severe cases there was intense burning and itching, followed by considerable pigmentation and desquamation. The most common complication was inflammation of the conjunctiva. The most suitable preventive measures were to apply a generous coating of vaseline to the face, and to wear dark sun glasses. The burns were treated by washing the face with soap and water, and applying Foille solution (containing calcium salts, benzocain, sulphur and vegetable oil). The eyes were treated, if there was any burning sensation, with 3 per cent. boric acid solution, followed by boric acid ointment. H. M. V.

A New Method for the Determination of Free Silica in Industrial Dusts. SALAZAR, ALFREDO and SILVERMAN, LESLIE. *J. Industr. Hyg.*, 1943. Vol. 25, p. 139.

In the apparatus described a current of air drives a sample (0·5 to 2 grams) of the dried dust through a steel tube heated to bright redness, together with a mixture of air and acetylene. The flame temperature of this mixture is over 1770° C., and it is sufficient to fuse the silicates in the dust so as to form microscopic spheres, whilst leaving the free silica in the dust unfused. The sample is collected by an electrostatic precipitator and removed to a microscope slide for analysis. The amount of free silica is determined by a direct count of the fused and unfused particles. Certain refractory substances (melting at 1800° to 3000° C.) interfere with the process, but they can be identified by their optical characteristics. A table of results is given, in which the dusts of various minerals were analysed petrographically by count, and by the fusion method described. H. M. V.

A Portable Electrostatic Precipitator. LEA, WILLIAM L. *J. Industr. Hyg.*, 1943. Vol. 25, p. 152.

The apparatus described consists of an electric precipitator, which is carried in one hand, and a power supply, in a case, which is carried in the other hand. By this portable method the workers in brass foundries, etc., can be followed closely, and samples of the fume be collected at the breathing level of the furnace tenders, skimmers and pouring crews. Such samples contain far larger quantities of lead and zinc than those collected in the general vicinity. Data collected in four foundries showed that samples collected in the skimming operation contained from 32 to 170 mgm. of lead per 10 cu. metres of air, and 130 to 1400 mgm. of zinc, though the room average amounted only to from 0·7 to 3·2 mgm. of lead and 2 to 35 mgm. of zinc. In the pouring operation the lead varied from 4 to 380 mgm., and the zinc from 28 to 1500 mgm.

The construction of the precipitator is described in detail. H. M. V.

Diethylaminoethanol as a Reagent for the Detection and Colourimetric Determination of Small Amounts of Trinitrotoluene in Air. GOLDMAN, F. H. and RUSHING, D. E. *J. Industr. Hyg.*, 1943. P. 164.

The sample is collected by bubbling the air through the reagent in a bubbler. The diethylaminoethanol used gave, with trinitrotoluene, a red-violet colour gradually changing to yellow-red. The sample obtained was compared with standard solutions of T.N.T. by means of a Coleman spectrophotometer. Transmittances were measured after the solutions had aged for periods ranging from 11 minutes to 360 hours. Though the colour gradually fades there is very little change between, e.g., 24 hours and 124 hours. The standard solutions of T.N.T. must be made up from the same batch of ethanol as that used in the sampling. H. M. V.

A Modification of the Silica Gel Method for the Determination of Atmospheric Organic Solvent Vapours. CRALLEY, LESTER V., SHEA, THOMAS E., and CRALLEY, LEWIS J. *J. Industr. Hyg.*, 1943. Vol. 25, p. 172.

A general method for the determination of atmospheric organic solvent vapours is afforded by the absorption of the organic vapour by silica gel, and its subsequent removal from the gel by a second solvent. In the present tests air containing a known amount of carbon tetrachloride was passed through an adsorption train containing magnesium perchlorate and 8 grams of silica gel. The gel was then added to 20 c.c. of 95 per cent. ethyl alcohol, and an aliquot portion, mixed with potassium hydroxide, was heated to 50° C. overnight. The chloride was estimated volumetrically by silver nitrate and potassium chromate. In a series of tests with air containing from 95 to 380 parts per million of carbon tetrachloride the amount detected ranged from 91 to 99 per cent. H. M. V.

The Chronic Toxicity of Aerosol-OT. BENAGLIA, A. E., ROBINSON, E. J., UTLEY, E., and CLEVERDON, M. A. *J. Industr. Hyg.*, 1943 Vol. 25, p. 175.

Aerosol-OT is the trade name for the dioctyl ester of sodium sulphosuccinate. It has extensive applications in the textile industry, paint and ink manufacture, ore dressing, dry cleaning and photography. It is also used for cleaning bottles, and in canneries. It is usually employed in concentrations of from 0·01 to 0·1 per cent. In the present investigation its chronic toxicity was studied in several species of mammal. Young rats were given from 0·25 to 1·25 gm. per kgm. body weight for 24 weeks, and their growth was slightly retarded, but there was no definite alteration in the red-blood cell and white cell counts.

Tests were made on six dogs, and there was a small diminution of weight. Tests on rabbits resulted in several deaths from severe diarrhoea and anorexia. Tests on three monkeys showed very little effect, except that the larger doses of the aerosol were apt to irritate the stomach, and cause regurgitation. Lack of toxicity in man is evidenced by the fact that periodical physical examination has failed to reveal any toxic symptoms in men who have handled the material daily for years. H. M. V.

A Filter Paper Method for Lead Fume Collection. SILVERMAN, LESLIE and EGE, JOHN F., Jr. *J. Industr. Hyg.*, 1943. Vol. 25, p. 185.

The filter paper method has been found to be reliable for many substances. In the present investigation it was tested for lead fume. This fume was produced in a dust cabinet (1200 cubic feet capacity) by burning a lead tetraethyl solution in alcohol. The relative efficiency of the filter paper was ascertained with two papers in series, through which the air was passed at the rate of 3·5 to 29 litres per minute. The lead was analysed mostly by a modified dithizone method, and the average efficiency was found to be 98 per cent. The concentration of the lead ranged from 10 to 340 mgm. per 10 cubic metres of air. Minute particles of the lead appear to have passed through both filter papers, for tests made by another method showed that the absolute efficiency of a single filter paper was 87 per cent. A simple field apparatus which is light and portable is described. H. M. V.

Plumbism resulting from Oxy-acetylene Cutting of Painted Structural Steel. TABERSHAW, IRVING, R., RUOTOLO, BENJAMIN P. W. and GLEASON, ROBERT P. *J. Industr. Hyg.*, 1943. Vol. 25, p. 189.

A group of 14 men were employed in cutting up the steel girders of an elevated railway by means of oxy-acetylene torches. The girders were coated with lead-bearing paints containing 7 per cent. of lead, and though the men were supplied with mechanical filter respirators all of them were ill at one time or another with symptoms of lead poisoning. The urine of the men averaged 0·39 mgm. per litre, and in the two examples quoted the haemoglobin had fallen to 81 per cent., and the red blood cells to 4,200,000 per c.mm. The air in the breathing zone of the men contained on an average 12 mgm. lead per 10 cubic metres. H. M. V.

Protection of Radium Dial Workers and Radiologists from Injury by Radium. EVANS, ROBLEY, D. *J. Industr. Hyg.*, 1943. Vol. 25, p. 253.

In modern dial painting plants the work is usually carried out in separate hoods for each worker, with forced suction ventilation for the removal of the radon liberated from the stocks of paint and finished work under the hood. Ingestion of radium is now due mainly to carelessness in getting radium paint on the fingers and clothing. Personal cleanliness is therefore essential. The hands must always be thoroughly cleaned before eating or smoking. A suitable solvent (a mixture of xylene, trichlorethylene and ethyl alcohol) is rubbed on to the dry skin and removed, before it evaporates, with soap and water. The inhalation of radium paint dust is an even more important mode of entry into the body than ingestion by the mouth. The greatest body of radium content is usually found, not in dial painters, but in inspectors and instrument assembly workers who remove small chips of radium paint in the course of their work. The total radium content of an individual can be estimated, and it is considered that an individual whose exhaled breath contains 1 micromicrocurie of radon per litre has 100 per cent. of the ' tolerance ' value of radium. Only about 15 per cent. of dial painters, etc., ingest or inhale more than this tolerance amount, and they, when found, should be transferred for 2 to 4 weeks to non-radioactive work, during which time they excrete most of their radium. The author considers that complete protection from radium poisoning risks can be achieved by following the official regulations. The paper includes much exact information about the various radium products, including gamma rays, but these rays are normally unimportant in dial painting plants. H. M. V.

Dust Reduction at the Coal Face by means of Water-Sprays. WARNER, C. G. *J. Industr. Hyg.*, 1943. Vol. 25, p. 303.

The value of water in reducing dust in coal mines is well known. By a generous use of water in an American mine the investigators found that the dust could be reduced from 4340 particles to 176 particles per c.c. Observations by the author in a South Wales anthracite mine were made by a method that could readily be adopted in mining practice. Water was stored in casks near the coal face, and the spraying was done by means of the stirrup pump used for fire fighting in Great Britain. When a heap of material was being removed the fresh dry surfaces were sprayed from time to time. The total consumption of water in three stalls of a longwall face was 10 gallons per hour, the working time expended on spraying being inappreciable. Dust sampling was carried out by means of the thermal precipitator, and the average total dust counts under dry and wet conditions were respectively 3065 and 1445 particles per c.c. The percentage size distributions of the particles were almost identical. Other series of observations were made in a narrow place of the coal mine, and similar results were obtained. There can be little doubt that a more copious use of water would have produced much more striking results. H. M. V.

Nitrite Field Method for the Determination of Oxides of Nitrogen. PATTY, F. A. and PETTY, G. M. *J. Industr. Hyg.*, 1943. Vol. 25, p. 361.

The Greiss–Ilosvay reagent, consisting of a mixture of sulphanilic acid and alphanaphthylamine, has been used for the estimation of nitrogen dioxide in air, but there are several unfavourable factors in the procedure previously recommended. The authors have improved on it by using a 50 c.c. hypodermic syringe as a convenient sampling medium, reaction chamber and colour comparison tube. Exactly 10 c.c. of the mixture of sulphanilic acid and alphanaphthylamine are measured into the syringe, a 50 c.c. sample of the air, to be analysed is then sucked in, and the syringe is shaken, after closure. If the colour is insufficient the air is expelled and one or more additional samples sucked in. The colour of the sampling is compared with other syringes containing standard amounts of sodium nitrite and the mixed reagent. Comparisons of the results obtained by this method and by the phenoldisulphonic acid method showed fair agreement. H. M. V.

A Method for the Determination of Trinitrotoluene Derivatives in Human Urine. PINTO, SHERMAN S. and WILSON, WILLIAM L. *J. Industr. Hyg.*, 1943. Vol. 45, p. 381.

Trinitrotoluene does not pass through the body unchanged. Part of it may be oxidized to trinitrobenzoic acid, and part may be reduced to products with one, two, or all of the nitro groups converted to amino groups. Also other products may be expected. The method of estimation adopted by the authors was to extract the T.N.T. derivatives from the urine with ethyl ether, evaporate off the ether, and heat with titanous chloride solution. This converts the derivatives to triaminotoluene. After diazotization this is coupled with dimethyl-alpha-naphthylamine, and its amount estimated photometrically. The method is described in detail, together with observations on the effects of interfering substances such as the pigment extracted from the urine. It was found that workers exposed to different amounts of T.N.T. during the course of their work showed variations in the T.N.T. derivatives in their urine. The amount varied from 1 to 101 micrograms per ml. urine. H. M. V.

Fluoride Ingestion and Bone Changes in Experimental Animals. LARGENT, E. J., MACHLE, WILLARD, and FERNEAU, IVAN F. *J. Industr. Hyg.*, 1943. Vol. 25, p. 396.

It is known that in man the prolonged absorption of fluorine compounds may cause skeletal changes which can be recognized in roentgenograms, and in some instances the post mortem changes have been studied, but no observations on man have as yet revealed the time-dosage necessary to produce the bone lesions recognizable by means of roentgenograms. In the present investigation rabbits were fed on diets containing fluorine (sodium fluoride and cryolite) to the extent of 12–50 mg. per kg. body weight per day for a period of 16 to 92 days. Macroscopic bone changes developed in every animal so fed, and the fluoride content of the skeleton increased greatly (e.g. from 0·14 mgm. per gram of bone to 1·91 mgm.). However, roentgenographic examination failed to reveal the presence of these early bone changes. The mandible was found to be a frequent site of the gross changes induced by excessive absorption of fluorine, and it is suggested that roentgenographic study of the jaw in man may prove to be a useful means of detecting such changes in an early stage. H. M. V.

The Influence of Supplements of Vitamins A, B, C and D on the Growth, Health and Physical Fitness. BRANSBY, E. R., HUNTER, J. W., MAGEE, H. E., and MILLIG, E. H. *Brit. med. J.*, January 15, 1944, p. 77.

The effects of feeding Multivitamin capsules containing the above vitamins to 1400 adults and children are summarized. In the case of the children the vitamins had no statistically significant result on the rate of growth, nutritional status, muscular strength, condition of the teeth and gums, or absence from school on account of illness.

In the case of 214 men working in a zinc smelting works no significant improvement could be found in the haemoglobin level, blood pressure, absence from work on account of illness, or output of material, compared with a similar control group. J. W. P.

Supervision of Pregnant Women in Factory Employment. O'SULLIVAN, J. V., and BOURNE, L. B. *Brit. med. J.*, January 22, 1943, p. 108.

At a light engineering factory an ante-natal clinic has been established to supervise pregnant women employees.

A total of 178 women living in north-east London have so far attended; 90 of these were delivered during the first year, 82 in hospital and 8 at home. All were employed in such work as soldering, welding, assembling, operating capstan lathes and drills. At the factory there is a full-time medical officer and an adequate staff of State-registered nurses, some of whom are certified midwives. Women report their pregnancy to the nurses, the doctor or the welfare department, and arrangements are made for their examination and confinement. Routine examinations are carried out by an obstetric surgeon, who visits the factory at fortnightly intervals. Where necessary lighter work or shorter hours are advised, and the management put this advice into practice. At first patients were advised to stop work at the fifth month; as time went on, however, most of them wished and were allowed to continue for longer periods. Night work is considered inadvisable and not permitted. All pregnant women have the advantages of the extra nourishment and vitamins issued through the Government scheme. Nursing mothers should not recommence work for at least three months after delivery. Day nurseries must be established if return to work becomes necessary. A national scheme should be set up to supervise the employment of pregnant women and to investigate the possibility of increased financial benefits.

D. S.

Fitting Industry to Human Needs. LLOYD DAVIES, T. A. *Lancet*, February 12, 1944, p. 223.

Whatever may be the ultimate pattern of industry men and women will always have to work. Men are more important than machines and industry must adapt itself to human needs. As far as physical and mental health are concerned effects of work cannot be divorced from factors in the home or at play. A man is influenced most of all by his sufficiency or lack of food. A proper balance of work, sleep and leisure must be maintained. It is the function of industrial medicine to study environmental factors affecting persons at their place of work. There is much need for the study of industrial conditions as some occupations are of a deadly character. Assuming the average mortality of males age 20-65 years to be 100 per cent., tin and copper miners have a mortality of 342 per cent., sandblasters 304 per cent., other metal-workers 283 per cent., stevedores 220 per cent., glass-blowers 160 per cent. and inn-keepers 155 per cent.

A workman can do little to help himself in industry. He has to accept conditions as he finds them. While employers do not wish workmen to suffer, many hazards arise from indifference, ignorance or prejudice. Protective measures may be shirked for financial or other reasons.

The medical examination of 1831 young persons applying for employment in a factory during the 3 years to May, 1943, showed that 190 had no defects; 1478 had some minor defect such as dental caries or defective vision; 129 had major defects such as heart disease; and 34 were unfit for employment. All these children, since the age of 5, had been supervised by the school medical service, but it is safe to state that the physical condition of juveniles in industry is poor.

D. S.

Cadmium Poisoning. ROSS, PHILIP. *Brit. med. J.*, February 19, 1944, p. 252.

Cadmium is used in plating; the preparation of certain fusible alloys; the manufacture of specialized solders, dry batteries, paints and metal bearings; and in the car and armaments industries. Health hazards occur during the smelting of ores, the preparation and flame-cutting of cadmium alloys, cadmium welding, electro-plating and metal spraying. It is not universally realized that finely divided cadmium of a particulate size of 10 microns or less is inflammable, producing in the presence of abundant oxygen dangerous fumes of cadmium oxide, which may be explosive.

As with lead and mercury the main danger lies in the inhalation of fumes of the pure metal and its salts. Free fumes must be prevented in workshops, and if unavoidable there should be sufficient exhaust mechanism and suitable respirators provided for the use of workers. The immediate effects are smarting of the eyes, dry throat, dyspnoea, cough, and a feeling of prostration. Delayed effects appear after 3 hours. The earlier lung distress increases. There is nausea, vomiting and occasionally diarrhoea. There may be rigor and pyrexia with marked prostration. With prolonged exposure pneumonia may supervene, and in fatal cases there may be signs of kidney and liver damage. Except where contact with fumes has been slight and brief the patient must stop work and rest in bed for at least 48 hours. Treatment is symptomatic. These observations are based on analysis of 23 cases of which 7 lost no time, 4 were absent for 1 day, 3 for 6 days, and 1 for 9 days. Of the more seriously affected 1 was away for 4 weeks, 1 for 7 weeks, and a man with pneumonia for 2 months. There was no fatality.

D. S.

Industrial Management and the Medical Department. JENKINS, I. D. *Clinics*, 1943. Vol. II, No. 3, p. 536. (Part of a Symposium on Industrial Health.*)

Management's interest in industrial medicine is shown in three primary ways. In the thought and care which it gives to planning a medical policy; in the care exercised in selecting medical and nursing staff; in the space and equipment required for the medical department. Not so long ago the medical department with its attendant costs was viewed as a necessary evil; now it is considered good business, and an essential part of industrial relations. Within the organization the service should provide adequately for entrance examination, a plan to prevent occupational disease and other hazards at work, and a proper method of care of all industrial accidents. To be successful such a programme must command the respect of the community and in particular that of the medical profession. There is no one right way to develop an industrial medical service as the need varies between plants, industries, and communities. Guiding principles, however, are common to all services. Employment standards should be for proper placement rather than for exclusion because of physical defect. Employees need not be physically fit for every job, and the doctor has considerable responsibility to find work, as far as is possible, for every applicant. The control of occupational hazards is based not only on physical environment but basically on clinical examination including follow-up. For special hazards specialist examinations may be necessary such as x-ray and laboratory work. These principles apply to the small plant no less than to the large.

D. S.

Industrial Hygiene and Sanitation. COOK, W. A. *Clinics*, 1943. Vol. II, No. 3, p. 548. (Part of a Symposium on Industrial Health.)

The purpose of industrial hygiene and sanitation is to ensure that danger is extracted from dangerous trades. Not many years ago the fate of most cutters of hard stone was early death from consumption, but to-day there need be no impairment of health, far less death, in this occupation or any other trade. Non-occupational factors are greatly responsible for general ill-health, but we must not be blind to the fact that occupational factors are also important. For example exposure to high concentrations of welding fumes reduces efficiency by producing malaise and physical ill-health, together with antagonism towards an employer who fails to alleviate the condition. The basic causes of unfavourable working conditions are ignorance and apathy on the part of the employer, and the personal conduct of the worker. Both need education. Industrial relations are greatly

* This Symposium takes up the whole of the October 1943 issue of *Clinics*, published by Lippincott, Philadelphia, Pa., with 300 pages. In addition to the articles abstracted here it contains contributions by various authors on the industrial nurse, safety, industrial fatigue, occupational diseases, nutrition, eye services, dental services, and descriptions of the various industrial health activities of U.S. medical associations.

influenced by the absence or presence of a hygiene programme particularly in war time. Fear of injury to health may materially upset production.

Modern industrial hygiene methods constitute recognition of the hazard and its accurate evaluation. There should be a written record kept up-to-date of all materials and operations which are potentially dangerous. The severity of the hazard must be estimated. For example analysis of the air of dusty work enables assessment of a silicosis risk, together with x-ray examination. There are toxic limits for most materials used and produced. Urine analysis and blood examinations are of ancillary value. Lapses in the provision of proper factory sanitation must be noted and deficiencies corrected. Water supplies are of first importance. Toilet and washing facilities must comply with the standards set up by the U.S. Department of Labour. Hot running water should be provided. Soaps and hand cleaners should not be of the harsh alkaline or abrasive types, and should exclude sand soaps and solvents. A separate lunch room is always desirable, coming up to the standard of the tentative code of the U.S. Public Health Service on eating and drinking establishments. Good housekeeping is of special importance where there is a hazard.

Intensities of illumination have been published by the American Standards Association in a code which should be used as a guide. Where there is much noise functional disorders of the central nervous system have been widely observed. Methods of reducing noise have been developed; pipe noises can be absorbed by muffles; damping pads can be placed under vibrating machines; sound absorbing wall and ceiling board is useful in offices. Welding is replacing rivetting, thus eliminating a most objectionable noise. Smooth floors and rubber tyred trucks reduce general noise. D. S.

The Problem of Absenteeism among Industrial Workers. GAFAFER, W. M. *Clinics*, 1943. Vol. II, No. 3, p. 599. (Part of a Symposium on Industrial Health.)

At the present time absenteeism from work on account of sickness is the generally accepted measure of industrial health. The decision to adopt time lost as the measure automatically excludes minor ailments and defects where the man remains at work. In measuring the time lost the *disability rate* is the average number of days lost per annum per worker, while the *severity rate* is the average number of days lost per absence. A third rate is the *frequency rate* or the average annual number of absences per 1000 workers. For preventive purposes the frequency rate is most useful. Rates involving time determine economic loss, but disclose little about the number of sources of infection. These three rates are related and any one may be obtained from the other two. For example the disability rate equals the product of the frequency and severity rates divided by 1000.

Comparison of absence rates in different industries must be based on a number of factors such as age and sex distribution, relation of illness to occupation, the cause and onset of the illness, and the accuracy of diagnosis. Absence rates must be correlated with distribution, notifiable causes, season of the year, epidemics, quarterly frequencies, occupation, and colour. Apparent difficulties in keeping accurate records and in drawing sound conclusions should not discourage the collection of data and analysis. D. S.

Women in Industry. BURNELL, M. R. *Clinics*, 1943. Vol. II, No. 3, p. 631. (Part of a Symposium on Industrial Health.)

In a study of 1900 occupations in 21 key industries, only 331 operations were found to be definitely unfit for women workers. In a questionaire sent to 90 firms, 78 replied that they proposed to employ women on work usually done by men. There are over 4 million women in U.S. war industries, half of this number newly employed during the past twelve months. Types of employment for women are bench work, assembling, inspection, packing, paint-spraying, spot-welding, light presswork, tapping, milling, rivetting, and brazing. Weight lifting raises problems. The strength of a women is about half that of a man. Weights around 20 lbs. are about the maximum that can be handled continuously. Although it is possible that women are more susceptible to toxic materials, with good hygiene they can be safely employed even where hazards are present. Pre-placement medical examination is important and should be a routine procedure, but should not include pelvic examinations. X-ray of the chest is strongly advocated.

Dysmenorrhea is a real problem in industry. Exercises and attention to the intestinal tract will cure most cases. In industry there should be a ward where employees can rest and be given local heat and simple medication. This returns the majority to their work. The menopause can give trouble to the industrial physician particularly as so many women over 40 years of age are to-day employed. The protection of the pregnant woman and her child has become urgent. Rules in such cases are non-exposure to toxic substances, the provision of adequate facilities for pre-natal care, no night work, a maximum of 48 hours work per week, a minimum of 6 weeks leave before delivery and 6 weeks after a delivery in uncomplicated cases.

Because 85 per cent. of industrial establishments in the U.S. are served by part-time doctors whose industrial practice is only incidental to their private practice it appears to indicate that little has been done about the care of the pregnant woman in industry to date. It is concluded that adequate care for the pregnant worker is number one problem in industrial medicine. D. S.

The Role of Non-occupational Sicknesses. SELBY, D. C. *Clinics*, 1943. Vol. II, No. 3, p. 682. (Part of a Symposium on Industrial Health.)

Almost twice as many workers get hurt on the streets, at play, or in their homes, than in the factory. Ordinary sickness causes much more lost time than occupational disease. Women lose more time from sickness than men. Respiratory disease is the commonest cause of sick absence. Appendicitis disables 1 in every 100 workers each year. Tuberculosis disables 1 in every 1400 each year, so does diabetes. Syphilis disables 1 in every 5000. The largest single source of absenteeism is sickness, and doctors are being asked what to do.

Control of respiratory infections in industry includes urging employees to obtain correction of physical defects which pre-dispose to colds, e.g. sinus infections, infected tonsils. Those who are susceptible should work with the minimum exposure to draughts and variations in temperature, and not in a crowded environment. Advice on appropriate clothing should be given, especially to women. Industrial hygiene investigations should correct conditions which pre-dispose to colds. The doctor can change employment, isolate, or give sick leave, in conditions with elevation of temperature. Attendance at the medical department for temporary alleviation of symptoms must be encouraged, and, if symptoms persist, attendance at the family physician.

The rates for digestive diseases in women are double those of men, and the question is raised: "Does the female eat the right kind of food?" Where large numbers of women are employed the appointment of a special nutrition "councillor" may be justified, who thinks of something more than vitamins. In one large group appendicitis was responsible for more than 100,000 days of disability in one year, an average of 45 days per case.

A superficial study of sick absence shows industrial doctors that it is largely a feminine problem. In the days when workers were men, 10 per cent. would be off each year because of non-occupational sickness and injuries. Each case would lose about 35 days. With an increase of women workers some 16–30 per cent. are off, and the time has increased to over 40 days. D. S.

REVIEWS

MINIMUM REQUIREMENTS FOR SAFETY AND INDUSTRIAL HEALTH IN CONTRACT SHIPYARDS

(U.S. Government Printing Office, Washington. 1943. Pp. 35.)

The health and safety requirements set out in this booklet have been agreed by the U.S. Navy Department and the U.S. Maritime Commission, and all contractors to these two departments are expected to comply fully and completely with the standards laid down. The standards represent a specialized study based upon a fact-finding survey in this field of industrial medicine made by experts. They have received the unanimous approval of the medical and safety departments and of labour management committees from shipyards on all coasts. In an introduction to this somewhat unique document, Frank Knox, Secretary of the U.S. Navy, and E. S. Land, Chairman of the Maritime Commission state: 'Aside from the weight which must be given humanitarian considerations, it is simply good common sense that as much care and attention be given to protecting the human factors in the war production program as is given machines.' The subject matter is divided into two sections, one setting out the minimum requirements for industrial health and the other the minimum requirements for safety.

Minimum Requirements for Industrial Health

Medical Facilities.—Yards employing up to 5,000 men should have two full-time physicians, and one additional physician for each additional 5,000 men. These yards should have in the main dispensary 6 full-time nurses, and 3 additional nurses for each additional 5,000. First-aid stations will need extra nursing staff. Adequate clerical staff is catered for.

The medical department should have—a waiting-room with suitable registration facilities; a general treatment room; an eye treatment room; a minor surgery room; a ward with beds, 3 for 5,000 workers; doctors' offices and private examining rooms; nurses' office and dressing room; x-ray room for yards employing 5,000 or more; a physiotherapy room; lavatories; stores; and filing rooms. In addition an ambulance has to be provided where there are 15,000 employees, with a passenger car always in reserve.

Details are given of the records and forms to be kept by the medical department. Physical examination is required to ensure proper placement of employees. Periodic examinations are laid down for men working on hazardous jobs, for example crane operators, locomotive engineers, sand blasters, radium and x-ray workers, and paint sprayers. The medical arrangements include air-raid precautions.

Responsibilities of Medical Services.—Frequent inspection of the yard by the medical staff is required so that they can become familiar with the various occupations. Close collaboration with the Safety Department has to be maintained with special regard to records of accidents and absenteeism. The medical staff are required to know the composition of paints, thinners, and other chemicals used in the yard, and to collaborate with the Safety Department in the protection of workers. As in the general practice of medicine the confidential relationships of doctor and patient are maintained. Canteens, water supply, sewerage and waste disposal come under supervision of the medical officer from the point of view of sanitary standards.

Protective Equipment.—Details of protective devices used in specific occupations are given. There is also a guide for prevention of industrial disease in shipyards including the following: the risks of electric-arc welding, lead poisoning, solvents, zinc fume fever, Fiberglas (the cement used with Fiberglas may contain a toxic solvent such as carbon tetrachloride), asbestosis, silicosis, and dermatitis.

Ventilation standards are laid down with special reference to the safety of those workers in welding, paint and electrical departments. Air analyses and tests have to be made by the safety and medical consultants of the Navy and the Maritime Commission if necessary.

Minimum Requirements for Safety

The document states that it is absolutely essential if a successful accident prevention programme is to be installed and operated that top plant management take an active and interested part in the work. The responsibility of management includes the provision of a safe working environment, training of employees for safety, the establishment of an adequate record and reporting system, and the appointment of a safety engineer or director with adequate staff. A full-time safety engineer or director has to be appointed for all shipyards, working in close co-operation with the medical officer. He is responsible to the highest executive or his representative. The numbers of staff are laid down in some detail together with a list of the duties required.

Record and Report Forms.—The exact type of record form to be completed in all shipyards is stated. Accident frequency rates for shipyards are determined as follows:

$$\text{Accident Frequency} = \frac{\text{Number Disabling Injuries} \times 1{,}000{,}000}{\text{Total Man-hours Worked for Period Covered}}$$

Safety committees have to be set up and minutes kept. These committees consist of a management representative as chairman, the safety director as secretary, all superintendents and foremen, a medical department representative, quartermen or leadermen, and one employee. They form the policy for safety work, decide on such matters as type of safety equipment to be used, and review fatal or serious accidents and make recommendations. These central safety committees may have a number of sub-committees, for example regular inspection committees and special inspection committees.

The Training of Employees in Safety.—Much attention has to be given to this part of accident prevention, and after initial medical examination the man has explained to him the safety policy of the company by a representative of the safety department. Safety rules have to be strictly imposed.

Safety Requirements.—Various types of protective appliances are given in detail, for example those to be used by welders, burners, and crane operators. Plant housekeeping has to be maintained at a high standard in all parts of the shipyard at all times, and special rules are given, for example, in relation to roads and passages to be kept clear of obstruction and free from debris; the use of white or yellow lines; the neat arrangement of welding leads and hose pipes to prevent men tripping or falling; deck areas to be kept free of debris, and construction material to be neatly piled; deck openings to be protected with guard rails, and hatches to be adequately guarded.

Lighting.—Minimum standards as recommended by the Illuminating Engineering Society are laid down in detail. The following are some examples.

Type of work	Minimum operating foot-candles—measured on the work
Assembly:	
Rough	10
Medium	20
Construction—Indoor:	
General	10
Forge shops and welding	10
Foundries:	
Charging floor, tumbling, cleaning, pouring and shaking out..	5
Rough moulding and core making	10
Fine moulding and core making	20
Machine shops:	
Rough bench and machine work	10
Medium bench and machine work, ordinary automatic machines, rough grinding, medium buffing and polishing	20
Paint shops:	
Dipping, simple spraying, firing	10
Rubbing, ordinary hand painting and finishing; art, stencil and special spraying	20
Sheet metal works:	
Miscellaneous machines, ordinary bench work	15
Punches, presses, shears, stamps, welders, spinning, medium bench work	20

The development of this type of industrial medical service in the United States will be watched with great interest and it is hoped that information on its activities will be forthcoming in due course. While shipbuilding here may not be on the same scale as in America the health hazards are comparable. It may be, therefore, that the proposals outlined in this document will act as an impetus to the setting up of adequate medical services for shipyard workers in this country. D. S.

YOUNG CITIZEN

By A. E. Morgan

(Penguin Books, Hermondsworth, Middlesex, 1943. Pp. 192. 9*d*.)

In 1938 the author made a survey of the adolescent citizens in the country, on behalf of King George's Jubilee Trust. This Penguin restates in shortened form the results of that survey and refers also to certain factual developments since war broke out.

In 1937 there were approximately 3¼ million boys and girls in the age-group 14–18. It was then predicted that a falling birth rate would reduce this by one-fifth in 10 years, and by one-third, or over ¾ million, in 20 years. Had it not been for the war the school-leaving age would have been raised in September, 1939, from 14 to 15. In January, 1941, the President of the Board of Education declared that he accepted the principle of raising it eventually to 16. Only thus can we adequately educate the youth of Great Britain. Day Continuation Schools, with compulsory part-time attendance up to 18 for those not full-time at school, is another requisite. Attendance must take place in the employer's time in the case of those at work, and not during leisure hours.

On leaving school at present the usual procedure is for the boy and girl to seek work. This is an immense event for a lad. The work is likely to be much harder than at school, but it is a worth-while price for what seems to be freedom. To be able to buy cigarettes and spit, and to cheek the foreman (at least once). The problem is to find the right job. It can be met by opening up the blind alley, by adequate training methods, and by proper placement. Apprenticeship or learnership schemes include study at a Technical College, and the employer may give time off for this. Unfortunately these schemes at present affect only a small proportion of juveniles. In Coventry, for example, there were before the war about 8,500 boys between 14 and 18. The engineering industry employed nearly 6000. Over the 5 years up to 1937 the average number of apprentices gaining certificates under the training scheme was 63 annually.

In discussing health and welfare the author states that the physical condition of juveniles is far from what it should and could be, although height and weight, general health and teeth have all improved, partly from remedial measures but mainly because of advances in social and economic conditions and education. The doctor, dentist and nurse can do little if good housing, food, light, air and clothing are lacking. Nutrition is a question basically affecting youth. The conditions under which young wage-earners work are important. The main reform is shortening working hours. It should not be permissible, for example, for boys to work in mines. In 1936 over 47,000 boys under 18 worked below ground. Accidents to young workers had risen, especially in coal-mining. Provisions to be ensured include hot mid-day meals at reasonable cost, supply of milk when it becomes again possible, adequate sleep, improvement in personal habits and dress, facilities for recreation, more adequate medical care after leaving school including dental and other benefits, medical inspection under the Factories Act to include adequate follow-up, and a fuller understanding of the particular requirements of youth.

The book also includes well-documented and interesting chapters on unemployment, public protection, delinquency, boys' and girls' organizations, leadership, conduct and religion, and finally outlines objectives for the future. In view of the vital importance of juvenile health in industry, and the fact that it must therefore be one of the foremost responsibilities of doctors and nurses in the factory, this book is at once an authoritative document and a fascinating subject for study. D. S.

VENTILATION AND HEATING: LIGHTING AND SEEING

Industrial Health Research Board Pamphlet No. 1

(H.M. Stationery Office. 1943. Pp. 20. 3*d*.)

During the war there has been much evidence that the results of research into industrial health are still not widely enough known and applied. This pamphlet, the first of a new series published by the Industrial Health Research Board, is intended to meet the apparent need for brief and easily understandable accounts, in non-technical language, of the findings of research workers. The pamphlet is intended primarily for laymen, including nurses, personnel and welfare officers, works managers and engineers, and for the workers themselves. However, many members of the medical profession also will find that it provides useful information about the effects of working conditions on the health of the workers.

One striking example of the importance of good ventilation and heating is given by the record of accidents in munition factories in the war of 1914–18. Accidents were at a minimum when the shop temperature was between 65° and 70° F., and increased by as much as 30 per cent when the temperature fell below 55° and by 20 per cent. when it rose above 75°. In some factories there is still very inadequate ventilation during the black-out, and suggestions are made for remedying this, and thus diminishing the risk of the spread of infection and feelings of fatigue.

Good general illumination of a factory stimulates production by causing workers to feel more cheerful and energetic, and also permits safe and rapid movement of persons and materials about the factory and makes cleaning easier. Fine work may need up to 100 times more light than the roughest work, and the value is stressed of measuring light by the simple light-meter. In addition, special spectacles may be needed, prescribed by an expert who, of course, must take into consideration the nature of the work as well as the vision of the worker. Much

valuable work in preventing eyestrain and assisting in the suitable placing of workers is being done by those factory medical officers who test the vision of all new workers.

This pamphlet may be regarded as an authoritative statement based on the results of scientific investigations over a period of more than twenty years. It should be appreciated by all who are interested in that most vital problem in war-time, the maintenance of good health in industrial workers. N. M. D.

KAISER WAKES THE DOCTORS

By Paul de Kruif

(Harcourt, Brace and Co., New York. 1943. Pp. 158. $2)

Mr. Henry J. Kaiser, the famous American shipbuilder, has recently provided for his 200,000 workers a comprehensive health service. He has evidently proved that a pre-paid assurance type of medical scheme on a mass scale is a practical undertaking. Many of his employees were rapidly recruited and drafted to his shipyards at short notice because of the urgency of his programme. This sudden influx of workers completely paralysed the local medical services, appointments to see doctors on quite urgent matters for example had to be made weeks ahead of time. Kaiser therefore had to act and he acted quickly. Dr. Sidney R. Garfield became his medical director and set up in record time a full and comprehensive service.

The plan revolves about two hospitals built by Kaiser with his own and Federal Government funds—the Permanente Foundation Hospital at Oakland, California, and the North Permanente Foundation Hospital at Vancouver, Washington. In addition, there are several smaller hospitals and a chain of first-aid stations in and near the yards. For 50 cents a week (2*s.* 6*d.*) at the California shipyard, and for 60 cents (3*s.*) at Washington and Oregon the workers receive complete hospital and medical care. These payments are deducted from wages on a wholly voluntary basis. Workers are not compelled to accept the scheme but the vast majority have done so.

Each employee is given a thorough physical examination before engagement. Physical handicaps do not prejudice employment but help in placement. The essence of the plan is the prevention of illness and accident by preventive medicine.

The first-aid stations in the shipyards form the basic unit, and serious cases are referred to the first-aid hospitals or the larger foundation hospitals according to the treatment needed. There are no limits to hospital treatment for both industrial and non-industrial illnesses as well as accidents, but venereal diseases, insanity, pregnancy and related ills, and extensive dentistry are excluded, although treatment of the gums when recommended by physicians is covered. There are additional charges for certain special forms of treatment which are provided at cost.

Some 125 well qualified doctors provide these services on a 24-hour basis, together with a full nursing and technical staff. The staff are highly paid, some of them at top rates, not from the original endowment but from the membership fees paid by the workers. There is an adequate ambulance service. Kaiser is attempting to extend the full programme to cover the families of all his workers. The Fontana employees may enrol their families in the scheme at the rate of 60 cents (3*s.*) weekly for the wife and 30 cents (1*s.* 6*d.*) for each child. The Vancouver, Washington, charge is approximately 3 cents (1½*d.*) per day for each member of the family.

Kaiser's male employees are largely ineligible for military service because of physical inadequacies or age, and a high proportion of the employees are women. Both groups would normally be considered bad risks from the commercial assurance point of view especially when their dangerous working conditions are considered. Nevertheless, the Kaiser plan has been a financial success. Although the two main hospitals are non-profit making organizations they are meeting all operating costs and creating a surplus for expansion. D. S.

STATUTORY RULES AND ORDERS, 1943

The following Statutory Rules and Orders have been issued since January, 1943:—

S.R.O. 187, 1943—The Electricity Supply (Hours, Safety and Welfare) Order, 1943, dated February 4, 1943, made by the Minister of Labour and National Service under Regulation 59 of the Defence (General) Regulations, 1939.

S.R.O. 268, 1943—The Magnesium (Grinding of Castings and Other Articles) Order, 1943, dated February 11, 1943, made by the Minister of Labour and National Service under Regulation 60 of the Defence (General) Regulations, 1939.

S.R.O. 573, 1943—The Factories (Canteens) Order, 1943, dated April 7, 1943, made by the Minister of Labour and National Service under Regulation 60 of the Defence (General) Regulations, 1939.

S.R.O. 1053, 1943—The Factories (Luminising) (Health and Safety Provisions) (Amendment) Order, 1943, dated July 14, 1943, made by the Minister of Labour and National Service under Regulation 60 of the Defence (General) Regulations, 1939.

PROCEEDINGS OF THE ASSOCIATION OF INDUSTRIAL MEDICAL OFFICERS, 1943–4

Thirty-fifth Meeting

The thirty-fifth meeting of the Association was held on January 22, 1944, at the London School of Hygiene. Dr. J. C. Bridge expressed his appreciation of the honour shown to him by the Association on his election as Chairman. He paid tribute to his predecessor, Dr. M. W. Goldblatt, who had given so much of his time and thought to the interests of the Association. He would to the best of his ability try to maintain this high standard during his term of office. His first official duty had been the sad one of representing the Association at the memorial service to the late Dr. G. C. Anderson, Secretary of the British Medical Association.

The Chairman then stated that, in accordance with the wishes of members, the Executive Committee had studied and taken legal opinion on the constitution. As a consequence various resolutions would be put to the meeting. As soon as the proposed alterations were agreed it was intended to publish a revised version of the constitution, in the form of a booklet, for distribution to all members. This was an urgent need as for some time it had been impossible to give new members a copy. The constitution was out of print and out of date. The resolutions put forward were debated in detail, and a good measure of agreement was obtained; but there were several items to which the Executive Committee was requested to give further study and submit amendments at the next general meeting.

The following were elected to represent the Association for the year 1944 on the Industrial Medical Service Sub-Committee of the British Medical Association: Drs. J. C. Bridge, W. Blood, M. W. Goldblatt, G. E. Graves-Peirce.

Dr. Patricia Shaw was elected to represent the Association on the National Advisory Committee for War-Time Rest Breaks for Industrial Workers.

A deputation to meet the Social and Preventive Medicine Committee of the Royal College of Physicians of London, at its request, was nominated as follows: Drs. J. C. Bridge, W. Blood, M. W. Goldblatt, R. E. Lane.

It was thought that machinery should be devised whereby members could be better informed of the activities of various committees and organizations upon which the Association is represented. The matter was referred to the Executive Committee.

A discussion then took place on 'Injuries, Infections, and Burns of the Hands,' opened by Mr. R. M. Handfield Jones, followed by Mr. P. H. Jayes whose paper appears at p. 106.

Mr. Handfield Jones said that the commonest minor injury in his experience affected the distal segment of the finger. Fibrous trabeculae divided the pulp of the finger into a series of narrow compartments. So operation for drainage of a pulp infection must open all the infected compartments at once. Pulp infections must be differentiated from lymphangitis. In the latter incision was contra-indicated; the patient should be regarded as a potential fulminating case and be put to bed; the arm should be raised to 45 degrees; antiphlogistine can be applied locally; and early massive doses of sulphanilamide should be given. Complete return of function in cases of tendon sheath infection could never be guaranteed; early incision was essential for good recovery. When the middle palmar space was involved swelling was not so marked as in the ballooning of infections of the thenar space. These conditions were usually caused by spread from other parts, and were rarely direct infections. Compound fractures of the hand should be treated as in-patients. The wounds, having been cleaned, should be packed with sulphanilamide powder, loosely stitched, and subjected to some form of traction. Early active movement was essential. It was easier to avoid stiff joints than to loosen joints that had been allowed to become stiff. Position in treatment was important; oedema could be minimized by raising the arm on a wooden frame—to have it lying on a pillow was not enough. If a stiff joint appeared inevitable, the hand should be kept in the proper position for function. Stiffness in an unsuitable position produced a useless hand.

Thirty-sixth Meeting

The thirty-sixth meeting took place on March 4, 1944, at the London School of Hygiene. At the private business session various amendments to the constitution were agreed, and the Honorary Secretary was now instructed to prepare the new constitution booklet and send it to all members as soon as possible.

It was decided to form an Education Sub-Committee as follows: Drs. J. C. Bridge, W. E. Chiesman, T. A. Lloyd Davies, Donald Hunter, R. E. Lane, T. G. Maitland, D. C. Norris, Kenneth Perry, C. L. Potts, Donald Stewart.

The Chairman reported on a meeting held between the Social and Preventive Medicine Committee of the Royal College of Physicians and a deputation from the Association. The following were the main subjects discussed: (1) Medical supervision of hotels and catering establishments, of stores, and of small factories. (2) The teaching of industrial medicine both to students and graduates. (3) Co-

operation between industrial medical officers and general practitioners, and local and regional authorities. (4) Medical statistics. (5) The teaching of psychological medicine in any scheme of post-graduate industrial medical study.

The next meeting of the Association is to be held on May 26 and 27, 1944, at Birmingham.

Public business took the form of a discussion on "The Influence of Industry on Obstetric and Gynaecological Conditions.' The openers were Mr. R. A. Brews, Dr. Catherine Swanston and Dr. Joan McMichael.

Dr. Catherine Swanston said she intended to confine her remarks to two particular classes of workers: firstly, pregnant women and, secondly, women undergoing the menopause. There was no reason why expectant mothers should not be employed on factory work, as in most cases the healthy body adapted itself to the extra strain imposed by the physiological process of pregnancy. Pregnant workers should be encouraged to report early to the medical department, and it should be made quite clear that pregnancy did not entail dismissal. It was important to remove them from certain toxic hazards, particularly liver or blood poisons. It was advisable to remove them from night work after the fourth month, as women in the later months of pregnancy required extra rest which they would not obtain if they were working in the factory by night and in their own homes during the day-time. Hyperemesis gravidarum, which caused lateness and absenteeism on the early morning shift in a certain number of women, could be alleviated by transferring the worker permanently to the afternoon shift where the three-shift system was in operation, or by giving permission to clock in later in the morning where the two-shift system operated. Heavy work, particularly weight lifting, should be avoided, and pregnant women should be kept away from ladders, overhead machinery and driving bands, unless very adequately guarded. Work involving a dermatitis hazard should be avoided. Much assistance could be rendered to transferred or unmarried women by the medical and welfare departments in factories, as these women were often at a loss to know where to go for advice when they became pregnant. No expectant mother should be refused her release from work if she applied for it.

A recent analysis of a group of pregnant factory workers showed that most of them worked until the fifth, sixth and seventh months, the largest number being discharged during the sixth month. All unmarried women work on until the later months of pregnancy; 12 per cent. of married women and 25 per cent. of unmarried women returned to their pre-confinement jobs. There appeared to be a preponderance amongst single women of those who left late and returned early, the probable underlying motive being financial.

Women undergoing the menopause often presented a much greater problem to the factory medical officer than the one with menstrual irregularities. Signs of increased irritability of the nervous system and a tendency to project menopause symptoms on to some other condition, such as a works injury, often caused these workers to become regular visitors to the factory surgery. It was essential that the underlying condition should be recognized and treated, and in these cases the help and advice of the consultant gynaecologist was most valuable.

An analysis of sickness absence of a large group of factory women showed that about 5 per cent. of all sickness was due to gynaecological causes. Pregnancy accounted for nearly half the time lost. Uncertified sickness, which was under 2 per cent., showed that a relatively large number of women, both married and single, took odd days off from time to time without obtaining a doctor's certificate. The probable cause for some of this absence was menstrual trouble.

An analysis of the reasons for the medical discharge of a group of over 1000 women factory workers showed that 36 per cent. were released for pregnancy and 6 per cent. for gynaecological conditions. Of the latter figure three-quarters obtained their release for menopause symptoms sufficiently severe to interfere considerably with their working capacity, or for menorrhagia. It would therefore appear that the majority of women released from work for gynaecological conditions are suffering from some menopausal disturbance.

The factory medical officer rarely obtained a clear picture of the gynaecological troubles of his work-people. This was due, firstly, to the ignorance and indifference still widespread amongst the female population; and secondly, because these complaints were usually carried straight to the patient's own doctor. It was essential in any investigation into the influence of occupation on health for two criteria to be fulfilled before there could be any true correlation between occupation and disease. Firstly, the medical officer in the factory must be aware of the correct diagnosis; and secondly, the consultant and private practitioner must have a true picture of the patient's work.

Dr. Joan McMichael said that obstetrics and gynaecology must inevitably play a considerable part in the work of an industrial medical officer in a factory where a large proportion of the employees are women. In her factory 62 per cent. of the workers are women, and sickness absence in January, 1944, was 5·9 per cent. out of a total absence of 12·2 per cent. Of this 0·11 per cent. was certified as gynaecological. In addition anaemia accounted for 0·32 per cent., debility for 0·53 per cent. and genito-urinary for 0·08 per cent., and it is probable that the certificates in these cases masked a certain number of gynaecological cases. The number of visits to the surgery for mild dysmenorrhoea averages about 270–280 a month, mild sedative treatment such as aspirin, propax and a hot drink being usually all that is required.

In relation to pregnancy there have been 85 new

cases attending the ante-natal session in the past 15 months, of whom the great majority (45 out of 55 in 8 months) left between the 20th and 32nd week. As many expectant mothers held skilled and responsible jobs affecting production, and many of them wished to stay for personal or financial reasons, it was agreed that some form of ante-natal supervision was desirable. In consequence Thursday afternoons were reserved for an ante-natal session at which the necessary adjustments in relation to the type of work, hours and night-shift could be arranged. A note to the personnel department ensures that expectant mothers are taken off any form of heavy work or weight lifting; off machines if there is any tendency to faintness or giddiness; and that they are allowed to come in an hour later (at 8 a.m. instead of 7 a.m.) if any morning sickness. Expectant mothers are normally taken off night-shift and overtime when they first report. Women are encouraged to attend their own ante-natal clinics regularly, and conversely the doctors at some of the clinics encourage patients from the factory to report to the factory doctor. Attention is paid to such questions as to whether they are getting their milk and eggs, cod-liver oil and fruit juices, and it is hoped to arrange the distribution of the two latter at the factory; and whether they would benefit from ultra-violet rays or special exercises.

Other problems of concern to married women such as birth control, sterility and sex maladjustments, including dyspareunia, frigidity and even impotence (at second-hand), are dealt with in the ordinary course of work, and patients encouraged to attend their own doctors for guidance—sometimes with the concrete assistance of a letter explaining the symptoms they find most difficult to explain to a man. In recent months several prospective Canadian and American brides have been examined for their routine Wassermanns; and one congenital syphilitic for her regular treatment, by arrangement with the hospital, to save production time.

The purely gynaecological cases are mainly dysmenorrhoeas, menorrhagias, metrorrhagias, leucorrhoeas with or without pruritus, and menopausal conditions. A highly qualified and capable physio-therapist achieves considerable success with the milder dysmenorrhoeas by massage and exercises and the reassuring influence of her own personality. For the more severe types the patients' doctor usually welcomes this form of treatment in addition to his own therapy. With the menorrhagias, it is important to investigate the type of work they are doing and to take them off weight lifting or heavy foot work. In addition haemoglobin estimations (Haldane's method) are carried out and results sent to the patient's own doctor.

BIRMINGHAM GROUP

At a meeting on December 1, 1943, Dr. J. G. Billington in the chair, Mr. J. Johnstone Gracie, Joint General Manager, G.E.C., Witton, read a paper on 'Payments by Results.' In view of the nature of the address invitations had been extended to works managers and welfare and personnel officers. Mr. Gracie gave an account of the history of the principles involved in the payment of wages. He discussed daywork rates and pointed out the increase in the practice of payment on a daywork basis in the U.S.A. He referred to the system used by some firms of payment by 'measured daywork.' This system was only applicable to certain operations such as the assembly of some standard unit. The times for the different series of operations in the whole process were studied individually and a programme of speed worked out. The rate was then fixed for the whole job, and any member of the team working on this unit had to keep to this rate. In this method of payment there was a definite incentive.

He then discussed the problems of payment by results. Differences in output had been definitely proved to occur in the various systems of payment. It was an established fact that the output on a system where there was payment by results was far in excess of the production obtained by payment on a daywork basis. The methods of fixing piecework rates of payment in the past had given rise to suspicion and warfare between management and labour. He described the different systems of fixing payments for results, and showed the undoubted evils in many of these systems which caused an unhappy atmosphere throughout the factory. What labour wished was a fair wage for the job, and such fair wage should be possible of fixation. In the past the rate fixed for a job was often a matter of haggling between management and workers rather than a rate fixed on a scientific study of the job. He put forward his personal views concerning the need for a national scheme of fixing basic rates for all types of work. It should be possible to assess the comparative value of every occupation. Then there was the question of the reward for the results obtained at work. This could only be obtained if the rates for the piecework were fixed on a national basis. The information required to set up such a national scale must be based on the scientific time study of the operation. A register of national rate-fixers should be formed, rather akin to the national register of doctors and nurses. In this way an unbiased rate would be possible of fixation.

On January 18, 1944, Dr. J. A. Scott in the chair, Dr. C. L. Potts opened a discussion on 'Preplacement Medical Examinations.' Dr. Potts said that there is little doubt that workers' organizations are not altogether satisfied about the value of medical examination before employment. However, in the House of Commons on October 14, 1943, the Minister of Labour, in reply to a question on this point, had no evidence that medical examination lead to the imposition of unnecessary high standards of physical fitness in prospective employees.

The purpose of medical examination is two-fold: (a) to provide work suited to the worker's mental and physical capacity, and (b) to prevent danger to

the worker's health from his work. Medical examination is therefore in the worker's interest; but clearly also it is in the employer's interest. It is sometimes assumed that medical opinion is biased in favour of the employer who pays for the service. But medical opinion is an unprejudiced opinion based on evidence. In medico-legal cases it may appear to be biased in a particular direction. This does not necessarily mean that doctors are particularly dishonest and will sell their opinions to the highest bidder. The human mind is so complex when evidence available is capable of more than one honest interpretation. Even where there is definite physical disability the attitude of mind of the worker can completely confuse the issue.

The form of medical examination depends on its purpose; for employment the standard should be the minimum standard of fitness for the particular job. A detailed medical examination is therefore seldom required. Unless his standard of health is accurately known before he starts work it is seldom possible to assess the extent of danger to health from work. If the possible dangers in some industries are not precisely known, a more thorough examination will have greater subsequent value from this point of view.

In carrying out preplacement medical examinations the medical officer's function is purely advisory. The determination of employment rests with the management. Obviously action is generally taken in accordance with medical opinion, and the statement that examination tends to transfer the determination of employment into the hands of the doctors appears to be justified. But is not this a good thing? If an employer wants to employ a man who is not fit, any doctor would run such a risk in sanctioning it that he certainly would not do so. Supposing the worker wants to do work for which he is considered unfit. In such cases the criterion should be the possibility of danger to other workers. Cases of active tuberculosis and epilepsy should not be allowed to work where the disability endangers others. With this qualification a worker should not be prevented from doing a particular job by reason of medical examination, provided he clearly understands the risk involved. It has been said that medical examination increases unemployment. If this were true it should be prohibited. The reverse, however, is the case. Suitable employment can be found for persons who otherwise would not be able to get employment. This will be a problem in peace-time when labour is plentiful. If employers obviously prefer fit men medical examination might tend to prejudice the less fit worker's chances of getting work. At the present time employment is determined by the Ministry of Labour which transfers workers and directs them for particular employment without any reference to their state of health. When a worker is rejected or released after a medical examination it is common practice for the medical officer's opinion to be submitted to the Ministry. This should help in placing such workers in suitable employment. The Ministry may make some use of this evidence, but not much. With the human material now available high medical standards would almost preclude an employer from obtaining any labour at all. The fittest men and women are taken for the services, and release from employment is granted for few other reasons than ill-health.

At a meeting held on February 10, 1944, Dr. C. L. Potts in the chair, Dr. Leonard Colebrook of the Medical Research Council showed a film on 'The Modern Treatment of Burns,' and opened a discussion on this subject. He explained that the M.R.C. Burns Unit had now been set up at the Accident Hospital instead of the Glasgow Royal Infirmary. He proposed to continue the work which he had started there, with particular reference to infection. Haemolytic streptococci remain viable for long periods in dust, and are freely disseminated by the sweeping of floors and the shaking of blankets and other bedding. There is no doubt that fresh burns are frequently contaminated by such causes. Blankets are seldom sterilized at the laundry, and because of their frequent contamination with pathogenic organisms should on no account be allowed to touch the burned surface. These and other points are dealt with in full by Colebrook, Gibson and Todd on p. 99.

A meeting was held on March 10, 1944, Professor H. P. Gilding in the chair, when Dr. Donald Stewart opened a discussion on 'Industrial Aspects of Rehabilitation.' With the development of industrial medical services it should be known how far they could take part in rehabilitation. The word was now used for many purposes; for example, rehabilitation of Europe, of housing, of industry and social rehabilitation. It could be divided into three main phases—reconditioning, retraining and resettlement. The problem under discussion, however, was the rehabilitation of the sick and injured worker. At present this was largely in the hands of hospital services either within hospitals themselves, or at special rehabilitation centres in the country not necessarily attached to any one hospital. With good treatment the need for special rehabilitation decreases. There is a risk that it may be plugged too hard at the expense of earning capacity, and occupational therapy in particular may be overdone. The policy of setting up social service departments at hospitals had been successful; for example, that at the Glasgow Victoria Infirmary. The function of the almoner was changing, and she was an important contact between industry and the sick and injured worker.

Industry, and in particular the employer, could contribute to rehabilitation by promising continued employment and removing the fear of insecurity; by arranging alternative work, under medical control, for temporarily unfit workers—larger firms could retrain their own permanently

disabled workers, Government schemes should deal with the smaller firms; by giving assistance on matters arising under the Workmen's Compensation Act; and by providing sheltered workshops for convalescent sick and injured workers in the larger organizations—these could be set up on a communal basis for the small factories.

Objections to alternative or light work are—it is difficult to find in many industries; it is difficult to keep under medical control and may actually retard recovery; it increases factory overheads and may not be popular with managers or the worker's mates; alternative work may become nothing more or less than a scrap-heap if the patient becomes 'lost' in the works on some quite unsuitable job; it is sometimes abused by Insurance Companies who ask for it in order to reduce county court settlements. But if properly selected and controlled, and with adjustment of overheads, it is possibly one answer to the problem.

Where firms attempt to set up rehabilitation centres on their own, without regard to hospital services, industrial medicine can be brought into disrepute. Isolationism in this respect can only bring failure.

Personnel management must play its part in supervision of return to work. In factories with less than say 300 workers this function becomes the direct responsibility of the manager. Education of works managers and foremen therefore becomes increasingly important.

The industrial medical officer should analyse the various occupations in his organization in relation to working capacity. Many jobs can be done by cripples who frequently compete successfully with normal workers. Certain jobs can be allocated to both temporarily and permanently disabled workers. The industrial medical officer must maintain close contact with hospitals in both medical and surgical cases.

The speaker contended that where more than 5000 workers were employed an essential development of industrial medicine must be a rehabilitation or sheltered workshop at the place of work under the joint medical supervision of works doctors and hospital specialists. In groups of this size it was estimated that every day up to 5 injured workers and up to 30 sick workers could be given true occupational therapy during treatment by hospitals or general practitioners. Rehabilitation must include convalescent sick workers, who outnumbered injured workers by at least thirty to one.

Mr. William Gissane, speaking next, had recently been at a meeting addressed by the Minister of Labour who had stated the Government policy in connection with the Disabled Persons (Employment) Act. Mr. Bevin had emphasized that employers could do a great deal of rehabilitation work on production lines, and this had been promised him by many industrialists. It is the Government's view, therefore, that employers will act as the chief agents in implementing the Act. Only when the employer cannot carry out the work will the Government set up its own rehabilitation arrangements. Whatever facilities are set up by employers will be examined by the Government, and if found adequate will be augmented by certain grants and maintenance costs.

During the last 12 months the Accident Hospital had co-operated with a large engineering works in an experiment on rehabilitation, now apparently a part of the Government policy. A sheltered workshop had been set up for injured employees of the firm, most of whom were his patients at the hospital. The principle was that the disabled worker was given remunerative work during treatment. It was possible to harness to production machines the repetitive exercises necessary for loosening up stiff joints and strengthening muscles, and by this method of remedial exercises the attention of the worker was on the job he was doing, rather than on his disabled limb. This was something very difficult to obtain in hospital treatment. Mr. Gissane then showed a short film dealing with his experiment.

Mr. Farrer, the manager of the rehabilitation shop shown in the film, was present by invitation. He described his part in the experiment and how he dealt with the workers. He interpreted surgical advice into terms of machinery and production. Out of 200 cases that had gone through the shop he had only been unsuccessful with one. He had frequently to remove certain fears from the minds of workers; fears connected with compensation, future employment, and wages. He had frequent talks with workers on many subjects such as accident prevention and cleanliness in the factory. The shop itself was a model shop from these points of view, and had done something to educate workers and management in good factory housekeeping.

Dr. S. Wand stressed the importance of including medical cases in any rehabilitation scheme. Without this wider view there could be no full rehabilitation service, nor could it form part of a comprehensive medical scheme. Professor Seymour Barling had recently seen many returned wounded soldiers. He was impressed by the high amputation rate which was greater than in the last war. There was much need, therefore, for retraining permanently disabled soldiers. Retraining must be considered a specialized problem. Dr. W. J. Lloyd maintained that the resettlement phase of rehabilitation should be accompanied by an intelligent assessment of injuries. There should be some system set up whereby skilled medical officers could interview workers and make recommendations to industry. Knowledge of the physical requirements of different jobs by industrial managers and doctors would do much to help in this assessment. There was no mysticism in rehabilitation. Group Captain O'Malley said that the R.A.F. were concerned with resettlement within industry of permanently disabled air crews and other personnel. They had set up a special mechanism to deal with this, and recommendations about special work which these men

could do would be communicated to the Ministry of Labour and to industry.

Sir Anthony Bowlby asked how far the experimental rehabilitation shop had paid for itself. Dr. N. T. Glynn, the medical officer at the factory concerned, and in medical charge of the shop, replied that approximately 80 per cent. of the cost had been met by the products manufactured. When a better flow-through of materials was obtained the net cost to the firm would be even less. Mr. Farrer said that it was proposed to plan for the manufacture of groups of units which together would compose some finished article produced entirely by the shop. In this way his workers would have an interesting incentive; they would know what they were making and have some goal to aim at. In answer to another question by Sir Anthony Bowlby he explained that payment in the shop was by day-rate and not by piece-work methods. Because of the financial incentive with piece-work men might further retard recovery of injured parts by working them too hard, and so defeat the real aim of the experiment.

GLASGOW GROUP

At the inaugural meeting held on November 11, 1943, Dr. H. M. Roberts in the chair, office bearers for 1943–4 were elected. Dr. R. S. F. Schilling, Secretary of the Industrial Health Research Board, London, present by invitation at this first meeting, spoke on ' Present Trends in Industrial Medicine.'

The first record of a works doctor dated back to 1830. At that time the public were complaining that children were being crippled by long hours and conditions of work in the textile mills. As a result a worsted spinner with an unusually high sense of duty appointed a medical officer to visit his mill daily to watch the effect of the work on the children's health. The report of the Poor Law Commissioners on sanitary conditions in the labouring population of Great Britain recorded in 1843 that a Mr. John Smith, of Deanston, near Stirling, retained the services of a medical gentleman to inspect the workpeople from time to time to give them advice and as far as possible prevent disease.

Under the Factory Act of 1844 Parliament gave power to factory inspectors to appoint certifying surgeons for the purpose of examining young persons about to be employed in factories, to certify the ages of these children, and to make reports on accidents. This was the first occasion on which the Government recognized the need for medical supervision in industry, but the powers of the medical officers appointed for this purpose were very limited. In 1898 Sir Thomas Legge became the first medical inspector of factories. His duties were largely to give advice to the Factory Department on problems of health, particularly in respect of industrial diseases. So in the last century the need for applying medical practice to industry was barely recognized. There was one medical inspector of factories and two or three industrial medical officers.

Since 1898 there have been vast changes. There are now 13 medical inspectors of factories and over 800 whole-time and part-time medical officers in industry. In some measure these changes are due to more enlightened public opinion which led to an extension of factory legislation, not only to safeguard the worker against dangerous machinery but also to protect him from the less dramatic evils of an unhealthy working environment. Nevertheless 400 Factory Inspectors and 1700 Examining Surgeons cannot give all that is required to safeguard the health of over ten million workers, and it must be realized that industrial disease is only a minor cause of ill health among industrial workers. As a result of a survey made in 1936 in over 100 firms in the U.S.A. it was shown that the average industrial worker lost fifteen times as much time from non-industrial as from industrial injuries and illness, thus showing the need for medical services which act continuously within industry itself.

There was no obvious development in industrial medical services until after the last war. This sudden development was possibly due to the previous findings of the 1915 Health of Munition Workers' Committee. By the beginning of the present war the number of whole-time medical officers in industry had risen to about 50. It was not until 1940 that legislative action was taken to ensure an expansion of industrial medical services. The Factory Medical and Welfare Services Order gave the Chief Inspector of Factories power to prescribe medical services in factories manufacturing munitions of war. Since then the number of medical officers had risen considerably, and in April, 1943, there were 164 full-time and 673 part-time medical officers working in factories.

In future medical services will have to give more attention to prevention and achievement of positive health. There must be a vast extension of the existing industrial medical services, for it has been estimated that only 25 per cent. of the working population are covered. With this expansion ahead now is the time to understand industrial medicine. At present there is a tendency for it to become entirely a casualty service or a panel service at the place of work. Industrial medical officers have not been trained in preventive medicine and therefore tend to concentrate on the branch of medicine which they know, at the expense of the aspects with which they are not familiar. The three tasks ahead are the improvement of working environment and the placement of workers in proper jobs, the prevention of occupational disease, and the prevention and treatment of injuries at work including some phases of rehabilitation.

Just under ten years ago there were scarcely more than 20 whole-time industrial medical officers in Great Britain, with no common meeting ground. Because of this two of them met in a pub one day and planned to overcome difficulties by forming an association or group for scientific study, social intercourse, and mutual help. The resulting formation of the Association of Industrial Medical Officers in 1935 was followed by a period of steady progress in

membership and activities. Regular quarterly meetings and discussions took place, and many of the ideas and suggestions relating to industrial health first propounded at these meetings have since become recognized as matters of national interest and importance. By 1937 membership was increased to 8 honorary members and 46 ordinary members, and by this time the Association was beginning to acquire influence. It gave evidence before the Interdepartmental Committee on Rehabilitation of Persons Injured by Accidents, and in March 1938 the A.R.P. Department of the Home Office invited the Association to discuss the problem of air-raid precautions in factories. In January 1939 the Association gave evidence before a Royal Commission on Workmen's Compensation.

With the onset of war and despite the difficulties of travel and extra duties it was agreed to carry on. As a result of the greatly increasing number of part-time doctors it was decided in March 1941 to open associate membership to them, and to-day there are some 400 members organized in various groups throughout the country. This was a wise move, for whatever may be the future organization of industrial medicine, there will always be a number of men and women engaged part-time in the practice of medicine within industry.

NOTTINGHAM GROUP

The seventh meeting took place on January 13, 1944, when Dr. G. F. Keatinge opened a discussion on the hazards of coal mining. Coal mining being a basic and essential industry was one of the most dangerous, accidents being about twice as frequent as in industry in general. The general plan of a colliery both above and below ground, coal getting by hand-cutting and by machine methods, and the methods of transporting coal underground were described. The specific nature and causes of accidents meant that specific measures for prevention had to be devised. Recent work on miners' nystagmus led to the conclusion that improved lighting was an important factor in prevention. It reduced accident incidence and raised morale to an outstanding degree.

General diseases most frequently met with amongst miners were rheumatism and respiratory conditions, but there was a rather high incidence of digestive complaints often with a psychological background due to working in semi-darkness and under dangerous conditions. Methods of prevention of sickness and accidents, and the findings of the Medical Research Council's Committee on Industrial Pulmonary Disease were discussed. X-ray films were shown to indicate problems in the differential diagnosis of silicosis.

TEES-SIDE GROUP

At the fifth meeting held on December 15, 1943, the subject for discussion was 'The Tuberculous Patient in Industry' opened by Dr. C. A. O'Neill, who said that there is a large number of tuberculous workers employed in industry, as in any normal cross-section of the population. Cases can be divided into: (1) symptomless or unrecognized, (2) active cases with symptoms but still unrecognized, (3) recognized but wanting to work, perhaps pending treatment or because they cannot afford to be off, or (4) resuming work either cured or incurable. All these classes present a problem, and industry requires control of such employees from the following points of view: (1) capacity for work, (2) health of other workers, (3) co-operation with those responsible for treatment, and (4) vocational selection. From the point of view of the employer the problem is complicated by social and economic factors; from the point of view of the tuberculous patient it depends on the varying attitude of different employers. Some employers are co-operative but others less so, to the detriment of the patients.

In spite of apparent deficiencies facilities for diagnosis and treatment of tuberculous cases in this country are considered to be the best in the world. Sufficient attention, however, has not yet been paid to after-care when patients leave the sanatorium. Convalescence is a very protracted affair and during this period suitable light work is most important. This is largely within the control of employers, and co-operation between works medical officers who know the various types of work and tuberculosis officers who recommend light work is most important. Mass radiography will shortly be introduced into the North-Eastern district. The chief objection to this is that it has been introduced before adequate sanatorium space is available for the accommodation of cases detected. It was thought that making submission to mass radiography a condition of employment was worth consideration. Industrial environmental conditions are often blamed as a cause of tuberculosis. There is no definite evidence in support of this with the exception of trades with a pneumoconiosis risk. The incidence of tuberculosis varies also with the standard of living. Work done at the Papworth Settlement and the British Legion Village near Maidstone, Kent, has led the way in rehabilitation. Industrial medical officers could be of assistance to tuberculous employees resuming work by arranging for the patient to be employed on work with as much fresh air as possible, and free from contamination by fumes and dusts. The work should also not be too heavy and it should also be interesting. Fatigue from all causes including noise should be avoided. There is usually a 60 to 80 per cent. remaining disability in all cured cases of fairly extensive tuberculosis. Some inducement should be offered to employers to take on partially disabled healed patients. The present practice, because of shortage of beds, of turning chronic carriers out of institutions to spread the disease among the public was severely criticized.

The sixth meeting of the group was held on January 12, 1944, when a discussion on 'Skin Disorders in Industry' was opened by Dr. W. Gillies Annan. He emphasized the need for co-operation

between industrial medical officers, general practitioners and dermatologists in dealing with skin cases. Dermatologists should be acquainted with processes and working conditions in local industries. This would be of assistance to them in dealing with skin cases from these industries. Nomenclature should be standardized. The term ' dermatitis ' by itself is unfortunate; by custom it has grown to be associated in the lay mind only with occupational skin diseases. The term should never be used without qualifying it by the type or cause. Adequate selection of employees would do much to prevent usually susceptible people being placed among irritants which might cause them skin trouble. A number of cases of so-called ' occupational dermatitis ' are caused, not by trade irritants, but by methods of cleansing and even by substances used for first aid. Irritant drugs should not be used for first-aid purposes. Among such drugs are mercurial compounds, picric acid, sulphur, and acriflavine. Suggested safe first-aid dressings are weak sodium bicarbonate, potassium permanganate, gentian violet or tannic acid.

It was important to make a full examination of all skin cases. Without this scabies, syphilis and impetigo could well be diagnosed as industrial dermatitis. There were limitations to the patch test. It is of extremely limited value and should not be used as a routine measure. Barrier creams are useful for protection of the skin but should only be used when all other methods of reducing contact between irritant and skin, e.g. by proper design of plant cleanliness, have been tried and in spite of this a risk still remains. Propaganda may be useful in educating people about the risks of dermatitis and methods for preventing it, but too much can produce anxiety about the danger of dermatitis and may be followed by an unhealthy attitude of mind towards the problem of dermatitis.

What is the value of desensitizing eczematous patients allergic to some particular irritant? Cases were quoted to show that desensitization may be accompanied by severe anaphylaxis. Desensitization occurs in some patients by natural means if they continue at work and in contact with the irritant while having treatment. Because occupational dermatitis due to dusts or liquids is associated with compensation, whereas eczema or dermatitis of non-occupational origin is not, there is a tendency for workers with skin trouble to try to get it labelled ' dermatitis ' to claim compensation which provides a higher rate of pay than National Health Insurance. This was a factor which considerably complicated diagnosis and treatment in many cases. We must look forward to a time when all disabilities whether occupational or non-occupational would be paid the same allowances when incapable of work.

In answer to a question as to what was a suitable cleansing medium for cleaning tar and grease off the skin, sulphonated oils were recommended. Degreasers should not be used for regular skin cleansing, but there was no objection to their use as a first-aid measure for cleansing wounds. The dermatologist should limit drugs for general use to a very small number: for infected or inflamed conditions, dilute potassium permanganate; when the condition is starting to resolve, dilute subacetate of lead; as a weak reducing agent, sulphur ; as a strong reducing agent, salicylic acid ; tar was useful for chronic cases; and the aniline dyes were useful antiseptics; a base for ointments was ung. zinc. co. (Lassar's paste), or vaseline.

The following remedy for ' athelete's foot ' was recommended:

Cignolin	gr.	4
Salicylic Acid	gr.	10
Zinc Oxide	gr.	120
Starch	ad oz.	1

This preparation should be applied to the affected area both morning and evening for 5 days without washing. Disinfection of socks and shoes must be carried out. Socks are disinfected by boiling, and shoes by enclosing in a biscuit tin with formalin for three or four days.

Dr. Annan drew attention to two useful books on industrial skin conditions: ' Essentials of Industrial Health,' by C. O. Sappington, M.D., published by Lippincott; and Prosser White's ' Occupational Affections of the Skin.'

The seventh meeting was held on February 9, 1944, when Mr. J. B. Reid opened a discussion on ' Orthopedics and Industry.' The latest method of treatment for sprained backs, including those with fractures of the transverse processes, was by injection of local anaesthetic into the painful areas. It had given good results in 70 per cent of cases, provided injections were made within 24 hours of the accident. Cases should therefore be sent to hospital within this time.

In this part of England fractures and orthopedic cases were dealt with by the local hospitals. In the interests of efficiency all orthopedic work should be centralized in one clinic. At the present time personnel and equipment were wasted by having the work done at several hospitals. An advantage of centralization is that a team of resident doctors can stay long enough at the clinic to ensure a continuous high standard of treatment. Under present circumstances house surgeons leave after six months and new ones have to be retrained.

Many orthopedic cases requiring in-patient treatment really mainly required rest. A convalescent home for such cases would release hospital beds. The present massage departments at the hospitals are not adequate. On the other hand the somewhat grandiose Government scheme was more than was required and would be more expensive. In this area it should be possible to have a rehabilitation centre attached to one of the present hospitals or to the proposed orthopedic clinic. Works medical officers should co-operate more closely with hospitals in rehabilitation. Factories could co-operate by providing light work which provided use for the injured part. This would assist in reducing incapacity

periods. A film was shown of a rehabilitation shop at a large engineering works in the Midlands. In the shop special suitable work is found for patients who have completed part of their hospital treatment but who require special rehabilitation to train them to full working capacity. Machines are provided with special handles and fittings for this purpose. As the patient's condition improves these fittings are gradually altered, up to the time of maximum recovery. During their stay in the shop patients are under medical supervision by the factory doctor in consultation with a hospital surgeon specializing in the treatment of accidents.

The following points were made in the subsequent discussion. The first thing that was required in this part of the country was re-organization of the local hospitals. There was a marked lack of co-operation between various hospitals, not only with orthopedic cases but with eye cases and other types of injury and illness. There was a great need for improving methods of rehabilitation. While the methods shown in the film were admirable in works of a certain type they were not necessarily applicable to industries on Tees-Side. Employers should be educated to understand that the provision of light work did not mean putting the injured worker on to a sweeping-up job. Each case should be treated on its merits and suitable work provided for every patient individually. Changes in hospital organization would have to come about by outside pressure, perhaps by the Government or the Nuffield Trust. There might be a place for a special rehabilitation factory for the common use of employers in the district; all cases requiring occupational rehabilitation would work here between the time they left hospital and when they were fit to resume normal employment. Such a factory would have to be under medical supervision.

INDUSTRIAL HEALTH RESEARCH

THE WORK OF THE INDUSTRIAL HEALTH RESEARCH BOARD, 1918–44

BY

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I. Introduction

In the very early part of the nineteenth century when excessively long hours of work were regarded as one of the indispensable conditions of making profits, Robert Owen, a cotton manufacturer, showed that he could make his factory pay by reducing hours. And he could still afford to pay better wages and spend considerable sums on improvements and amenities for his work-people. But it was not until 1892 that the first controlled experiment on the relation between hours and output was conducted by Messrs. Mather and Platt. Mather (1894) showed that the reduction in weekly hours from 53 to 48 caused an increase in production and a decrease in lost time. As in the case of Owen's experience, Mather's experiment did not lead to any general adoption by industry of similar methods, or to any organized scientific study of the subject either by the Government or private firms.

At the beginning of the last war, demands for strenuous and long-sustained industrial effort by workers emphasized the country's ignorance of the effects of hours and conditions of work on health, energy and output. In 1915 the combination of this ignorance and the urgent need to make good a shortage of munitions forced the Government to appoint the Health of Munition Workers Committee, under the chairmanship of Sir George Newman, with terms of reference as follows:

> 'To consider and advise on questions of industrial fatigue, hours of labour, and other matters affecting the personal health and physical efficiency of workers in munitions factories and workshops.'

These investigations, which were necessarily limited to the making of munitions, produced results which have not lost their value but have certainly been lost sight of with the passage of time. To take one instance, it was shown that in certain processes long hours may be both harmful and uneconomical.

It is, perhaps, worth recording that the final report of this Committee was addressed to the Right Hon. Winston S. Churchill, who at that time (1918) was Minister of Munitions. The Committee concluded that it was necessary to make arrangements without delay for a national scheme of industrial medical research, and to accord fuller recognition to the importance of industrial hygiene.

Shortly after the dissolution of the Health of Munition Workers' Committee in 1917, the Medical Research Committee (now Medical Research Council) and the Department of Scientific and Industrial Research, with the encouragement of the Home Office, appointed in July, 1918, the Industrial Fatigue Research Board with Sir Charles Sherrington as Chairman and Mr. D. R. Wilson as Secretary. The Board, which embraced all classes of industrial work within its scope, had the following terms of reference:

> 'To consider and investigate the relations of the hours of labour and of other conditions of employment, including methods of work, to the production of fatigue, having regard both to industrial efficiency and to the preservation of health among workers.'

As a first step the Board took over researches then in progress from the health and welfare section of the Ministry of Munitions. These included a study of the effect of different systems of employment on output in shell-making, and an inquiry into the incidence of multiple accidents. In addition it was decided to start investigations in the iron and steel, cotton, silk, laundry, and boot and shoe industries. The Board appointed for each industry a committee which included panel members representing employers and workers.

Just over two years later, because unemployment and short-time employment had become prevalent, the Treasury gave provisional notice to the Medical Research Council that the continuation of the Board could not be contemplated, and that steps should be taken to transfer any important work to industrial or voluntary associations. The Medical Research Council made strong representations to the Treasury against the abrupt termination of work without inquiry into its value to industry. The Treasury eventually agreed to the continuance of the Board on condition that the Council accepted

* Appointed Secretary of the Industrial Health Research Board in July 1942, in succession to Sir David Munro.

full administrative and scientific responsibility. This action not only avoided the sacrifice of valuable work in hand, but allowed new researches to be started. Nevertheless the preoccupations of the Government and of employers' and workmen's organizations, with the urgent economic problems of the post-war period, prevented the Board from developing in the manner anticipated at the time when it was first formed.

Researches which were not invalidated by the variable conditions of work, such as short and irregular hours, were continued. Eventually the direct problem of fatigue became less important as hours of work were reduced and as the enormous expansion of repetitive work made demands more on temperament than on muscular strength. This led to the investigation of boredom in relation to incentives and uniformity and variety of work. The field for research was also widened to include studies of effects on the worker of environmental factors closely related to health, for example atmospheric conditions, lighting and noise.

It was felt that the possession of a title expressing what the Board aimed at eliminating instead of what they wished to promote was a disadvantage. So in 1928, the word 'health' was substituted for 'fatigue,' and the Board became the Industrial Health Research Board. In 1930 Mr. D. R. Wilson (later Sir Duncan Wilson and Chief Inspector of Factories) returned to the Home Office as Deputy Chief Inspector of Factories, and Sir David Munro succeeded him as Secretary of the Board.

II. Between Two Wars

From the time when it was first formed until the outbreak of the present war, the Board published more than 80 reports. These give a detailed story of pioneer work which could have done much to improve working conditions in factories and mines had the results been more widely applied, particularly in the smaller industrial organizations. The result of one piece of research which has been universally applied is worth recording. The present 'Music while you work' programmes of the British Broadcasting Corporation are the direct outcome of studies by three of the Board's investigators (Wyatt, Langdon and Stock, 1937).

Hours of Work

Early investigations showed that the longer hours worked in the last war, originally introduced to increase production, actually reduced the rate of working so much that in spite of the longer working hours the gross output declined. As this has been stated in general terms so often but is still not acted on, it is perhaps as well to quote just one of the results (Health of Munition Workers Committee Interim Report, 1917).

> 'In the operation of turning aluminium fuze bodies the output of a hundred women was recorded. The results were as follows:—

100 WOMEN TURNING FUZE BODIES

Period	Actual hours of work per week (average)	Relative output per working hour	Total output (hours of work relative output)
Nov. 14 to Dec. 29	68·2	100	6820
Feb. 27 to Apl. 16	59·7	123	7213

> Reductions in hours were first made on January 30th, and once the effect of shorter hours of labour had become established total output was increased by 8 per cent. although the weekly hours of labour were reduced by 8½.'

After the evacuation of Dunkirk by the British Expeditionary Force in June, 1940, the demands made on the workers for a bigger output were cheerfully accepted. The long hours which followed were probably necessary, but the period for which they were allowed to continue might have been shortened had reference been made to the experience of the last war.

The importance of breaking up spells of work by means of suitable rest pauses was shown by Vernon in the last war (Health of Munition Workers' Committee, Interim Report, 1917). Later work by Wyatt and Fraser (1925) and Vernon, Bedford and Warner (1927) has illustrated the value of systematic rests, especially in light repetitive work. The results strongly suggest that in many industrial processes the introduction of rests of 5–10 minutes in the middle of the working spell is not only appreciated by the workers but may also be followed by an increase in output of the order of 5–10 per cent. in spite of the shortening of the working time.

The Factories Act, 1937, gives statutory recognition of the value of rest pauses. Under the Act, the working spell is normally limited to 4½ hours for women and young persons, but it may be increased to 5 hours where a rest pause of at least 10 minutes is allowed in the course of the spell. It is true to state, however, that the optimum relation between rest and activity during working hours in many different kinds of work has not yet been precisely determined.

Environmental Conditions

It is not always easy to persuade industry to reduce hours of work or to introduce rest pauses. Apparently some industrialists still believe that the relation between output and working hours is a linear one, i.e. that if one man fills 60 shells in one hour, he will therefore fill 60×12 in 12 hours. Workers will, in some cases, oppose reductions in working hours because of the resultant decrease in wages—particularly where hourly rates of pay are low. But there should be few insuperable obstacles in the way of improving environmental conditions, except, of course, for shortage of skilled labour and materials in war-time.

There are many examples to be taken from the

Board's eighty reports which show the ill-effects on health and efficiency of bad lighting, poor ventilation and inadequate heating of workrooms.

Lighting and Vision. The system of localized general lighting used in weaving sheds and other industries where the lamps are mounted just above the loom or working bench can provide uniform illumination over the working area—and darkness overhead—that unhappy partnership of glare and gloom. Weston (1922) showed that in the case of linen weavers, output achieved in normal daylight was substantially higher than that in artificial light. He also showed that it was uneconomical to delay the use of artificial light until natural illumination reached the 'grumble point.'

Other work by the same investigator demonstrated the value of spectacles for relieving eyestrain and improving industrial efficiency in very fine processes. They are no substitutes for good lighting, but they help the young worker who has normal vision as well as the middle-aged worker (Weston and Adams, 1927, 1928, 1929).

Heating and Ventilation. Atmospheric conditions have considerable effect on efficiency and in many industries the adverse effects of high temperatures have been shown. In the tinplate industry, Vernon (1919) found that without artificial ventilation the output of the metal-rolling teams was 12 per cent. less in the summer months than in winter; but when they had good ventilation from fans revolving overhead their summer output was only 3 per cent. less than in winter.

The effects of atmospheric conditions on health and well-being were studied in a variety of industries. Vernon, Bedford and Warner (1928 and 1931) in separate investigations analysed the sickness records of over 33,000 miners. They found that a rise of 10° F. to 13° F. in the dry bulb temperature was associated with an increase of 63–74 per cent. in the sickness rate of miners. They attributed the increased sickness to the men getting chilled before they were able to change their damp clothes at home, for miners who were provided with changing-rooms and baths at the pithead lost less time from sickness than those for whom pithead baths were not available.

Accident liability is increased by exposure to unduly high or low temperatures. Osborne and Vernon (1922) found that munition workers had the lowest number of accidents at an air temperature of 67° F. The accident rate rose at the lower and higher temperatures. At 52° F. it was 35 per cent., and at 77° F. 23 per cent. higher than at 67° F. Vernon, Bedford and Warner (1928) also showed that a much greater number of accidents occurred in deep and hot mines than in shallower and cooler ones.

The industrial medical officer should be constantly concerned with methods of ventilating and heating workrooms. He should know how to measure warmth and air movement, and also the requirements for comfort in different types of work. The work done by the Board on these and allied subjects was fully described by Bedford (1944) in the first issue of this journal.

Accident Proneness

The medical officer in industry deals with accidents largely from the point of view of providing first-aid treatment for major injuries and continuous treatment in the case of minor injuries. Lately, a few industries have made a forward step in assisting injured workmen to regain full function after injury by providing rehabilitation shops and special centres. All these are important aspects of the industrial medical officer's work, particularly in the heavy trades where the severity and frequency rates of accidents are high. But doctors in industry have not paid sufficient attention to the *prevention* of accidents. Admittedly the law requires that dangerous machines shall be guarded, but as the Chief Inspector of Factories said in his Annual Report for 1918: 'However well machinery may be guarded, we cannot look for more than a 10 per cent. reduction in the accident rate by the provision of safeguards alone.' It was recognized then as it is now that if every machine is made as far as possible foolproof, there will still be many accidents. The studies of Greenwood and Woods (1919), Newbold (1926), and Farmer, Chambers and Kirk (1926, 1929, 1933) have established the fact that, with equal exposure to risk, roughly three-quarters of recorded accidents happen to one-quarter of the people exposed. This is true for accidents, in the factory, on the road and in the home.

In practically all factory ambulance rooms detailed records are kept of all minor injuries. How often are they used to detect the accident liability of those employed on various jobs and in different departments, or the accident proneness of individual workers ?

Industrial Sickness

For several years the Board's investigators accumulated and analysed sickness records from a few firms. The absence rates showed a very wide range of variation due partly to dissimilar methods of book-keeping and partly to different conditions of work (May Smith, Leiper and Greenwood, 1936). In other fields, research showed that telegraphists' cramp, formerly thought to be a disease of the central nervous system, was a psychoneurotic manifestation (May Smith, Culpin and Farmer, 1927).

Of the several statistical inquiries made, the most recent was an investigation into the sickness experience of London Transport workers (Bradford Hill, 1937). This work, which was done at the request of the Transport and General Workers' Union, whose Secretary was Mr. Ernest Bevin, at that time a member of the Board, showed that bus conductors and drivers had an excess of gastric illness over tramway conductors and drivers. As a result, conferences were held by the Ministry of Labour in order to inquire further into this health problem and its relation to conditions of employment. In

a published report of the proceedings (Min. of Labour, H.M.S.O., 1939) it was stated that nervous strain and irregularity of meals were considered to be prominent factors in causing gastric disease. Methods of reducing the strain were suggested.

Vocational Psychology

Vocational psychology is a subject with which many industrial medical officers are not well acquainted, although it has been effectively applied to industry by the National Institute of Industrial Psychology. It includes vocational selection—which aims at finding the right person for the job, and vocational guidance—which attempts to discover the right job for the person.

The main task in vocational psychology is to devise tests which measure intelligence and special abilities, such as mechanical aptitude, and to determine the significance of these in the performance of various tasks. The Board's investigators and others have demonstrated that such methods supply only part of the information required for fitting the square pegs into the square holes. Intelligence tests and sensori-motor tests have been shown to have a predictive value for skilled occupations. Where the predictive value of these tests was compared with the results of entrance examinations in 1130 aircraft apprentices, performance in the psychological tests was more closely related to subsequent proficiency than performance in the entrance examination (Farmer and Chambers, 1929).

Contrary to the belief of many, the use of psychological tests limits the role of personal prejudice and tends to decrease the importance of the part played by academic education in allocating men and women to skilled jobs. Nevertheless their value depends on how they are applied to industry. If used for allocation rather than for rejection of the less fit and less intelligent workers, their scope will be enormous. But it is to be hoped that future work in vocational psychology will be aimed at detecting the capacity of children at an early age so that they can be guided towards careers offering *them* the best opportunity of success rather than selecting them for jobs—often blind alley jobs—in the interest of the employers' output.

Time and Motion Study

In this branch of their work the Board's investigators had the advantage of being independent of the industries concerned, and were therefore able to direct their attention primarily to the task of lessening the physiological cost of work and not of increasing output and lowering costs of production by forcing the pace for the worker. The value to the worker of a well-directed training scheme in methods of work is well illustrated by Farmer's work (1921) on movement study in metal polishing. He showed that, as a result of instruction, twelve girls roughing spoons were able to reduce the number of strokes per spoon from an average of 119 to an average of 83, and the average time was reduced from 126 minutes to 89 per three dozen spoons. And if the average earnings of these girls for the three weeks preceding training were taken as 100, then for each of the three weeks following training they were 127, 126 and 136½ respectively.

Another example of the good effects from the worker's point of view resulting from a study made by the laundry trade may be quoted. Efficient methods of feeding calenders for ironing sheets were demonstrated by films to a group of workers whose own methods of work produced results poor in quality at the cost of sore and bleeding fingers. This instruction led to a very welcome sense of relief among the workers; they were less tired and their fingers ceased to be sore. Incidentally both quality of work and output—estimated at a 10 per cent. increase—were improved (Maule, 1937).

Industrial Solvents

The Committee on the Toxicity of Industrial Organic Solvents was formed in 1935 as the result of the increasing use by industry of volatile organic solvents. As a first step, a full bibliography of relevant literature was prepared by Ethel Browning (1937). The investigations into the toxic effects of the chlorinated group of solvents which were started at the Chemical Defence Research Station at Porton had to be abandoned at the outbreak of war.

Other Work

This brief survey by no means tells the whole story of the work done between the two wars. Other pioneer researches were made into problems such as noise and its effect on efficiency, comfortable height of working benches, suitable design of machinery and optimum loads for different classes of worker, and the incidence of psychoneurotic symptoms in various industrial groups and their relation to sickness efficiency and social adaptability.

III. Since the Outbreak of War

In the early days of the war health problems associated with excessive hours of work, drafting of new labour into war industries, and toxicological problems which follow in the wake of the manufacture of new weapons and munitions, had not become acute. At this time the Board thought it desirable to remind industry of the lessons to be learnt from previous researches, in order that as the demands on our productive power grew ever more urgent the results of those researches could be applied and a repetition of the errors of 1914–18 avoided. So there was published (I.H.R.B., 1940) the first of a series of emergency reports, which gave a résumé of past work in terms as simple and non-technical as the subject-matter permitted. In the introduction to this report, industry was invited to consult the Board about new problems. The response was not overwhelming and for the time being the Board's investigators gave up much of their time to carrying out research and giving advice on non-industrial problems of national importance, such as the ventilation of air-raid shelters and military control posts and the clothing of military

personnel. Much was and is still being done to impart knowledge previously gained by lecturing to industrial medical officers, nurses, welfare supervisors, students in social science, as well as Royal Air Force and Army personnel who are being trained for selection work. Partly as a result of work done by the Board's investigators, the Army Council have adopted selection tests for recruits, and these are now being used on a wide scale.

Quite suddenly the 'bore war' ended, and Britain's small expeditionary force had lost practically all its equipment in France. The long-expected demands fell on industry, and as a consequence hours of work in some cases reached high levels. The effects of these longer hours were revealed by investigations (I.H.R.B., 1942*a*) into the relation between hours of work and lost time and labour wastage, which had been started in war factories at the outbreak of war. It was shown that lost time due to sickness, injury and absence without permission, was usually low when the weekly hours of work were less than 60 per week but increased as the hours increased up to 75. High praise was rightly paid by the investigators to the time-keeping of the factory workers, when it was remembered that many of them lived far from the factories and had to put up with air-raids and inadequate transport arrangements. In conclusion, the findings of this investigation showed that the weekly periods of work were much too long and substantial reductions were recommended.

Accidents in industry were increasing, and it was thought advisable to publish a short report on the personal factors which needed to be considered in the prevention of accidents (I.H.R.B., 1942*b*).

Reconstitution of the Board

In July, 1942, the Medical Research Council reconstituted the Industrial Health Research Board under the chairmanship of Earl De La Warr. It now has 13 members, comprising an employer, a trade unionist, professors of medicine, psychology and physiology, the Senior Medical Inspector of Factories, the Deputy Chief Medical Officer, Department of Health for Scotland, an industrial medical officer, a statistician, and other members of the medical profession. This Board has been given the following terms of reference :

> 'To advise and assist the Medical Research Council in promoting scientific investigations into problems of health among workers, including occupational and environmental factors in the causation of ill-health and disease, and the relation of methods and conditions of work to the functions and efficiency of body and mind; and in making known such results of these researches as are capable of useful application to practical needs.'

The changed terms of reference officially brought problems of industrial disease within the ambit of the Board. This is not to say that industrial diseases had been entirely neglected in the past. The Board had previously been associated with two committees appointed by the Council to advise them on the promotion and direction of research into industrial pulmonary diseases and the injurious effects of industrial solvents. The Committee on Industrial Pulmonary Disease has sponsored valuable researches, the most important of which have been those concerned with respiratory dust disease (byssinosis) suffered by cotton operatives (Prausnitz, 1936), and with chronic pulmonary disease in South Wales coalminers (Hart, Aslett, *et al.*, 1942; Bedford and Warner, *et al.*, 1943). The work by Prausnitz showed that the only way of preventing byssinosis was to remove the finest dust, which the ventilating and exhaust appliances in use at that time were incapable of doing.

Pneumokoniosis

Research in the South Wales coalmines established the occurrence among coalminers of a lung condition due to dust which did not fall within the definition of 'silicosis' as used for compensation purposes. This lung condition has been termed pneumokoniosis of coalminers. In its early stages it shows on the radiograph as reticulation, and later there develop the familiar nodular and conglomerate shadows of well established dust disease in miners. Further, there is found in necropsy material a change in the lungs which Belt and Ferris (1942) called dust-reticulation (a chance similarity in name to the radiographic appearance). It was also proved that coal trimmers (i.e. coal-boat loaders) working at the docks in South Wales could suffer from pneumokoniosis. The physical studies associated with this work were undertaken by two of the Board's investigators (Bedford and Warner, 1943).

This investigation led to important changes in the Workmen's Compensation Act, which now provides for the payment of compensation to all workmen in the coalmining industry who contract pneumokoniosis as the result of their employment in or about the mines.

Another consequence has been the renewed interest in the use of water for the prevention of pneumokoniosis by suppression of dust at the coal face. One of the Inspectors of Mines (Jenkins, 1943) introduced the novel method of infusing the coal face with water through bore holes before working the coal. The results have been so promising that an order (S. R. & O., 1943, No. 1696) has recently been made empowering the Chief Inspector of Mines to direct coalmining undertakings in South Wales to use this or other methods for suppressing dust below ground.

Clinical Research and Occupational Disease

As time went on it became obvious that there was need for more and more clinical research into occupational diseases and other disorders of a more general kind, although they have always been kept in check in factories by the constant supervision of the Factory Inspectorate. As a first step, the Medical Research Council appointed in February, 1942, as Director of Research in Industrial Medicine, Professor A. W. M. Ellis, who later became Regius Professor of Medicine in Oxford.

The next step was to establish in May, 1943, a Department for Research in Industrial Medicine at the London Hospital in charge of Dr. Donald Hunter, physician to the Hospital. Thus industrial medicine was rightly brought into close contact with clinical medicine in a big teaching hospital.

Industrial psychology

A further development is the recent establishment by the Medical Research Council of a unit for research in applied psychology at Cambridge, in charge of Dr. K. J. W. Craik, which will undertake investigations, many of them within the field of the Board.

Present Work of the Board

Sickness Absence. Lack of data giving the incidence of illness among industrial workers has for years past hampered investigations into the disablement believed to be caused by harmful processes. Without such data the collective health of various groups of workers, and indeed the health of the individual, cannot be assessed. In 1942, as a result of the demand and the urgent need for a practical method of recording sickness absence, the Board set up a committee to consider this subject. This task, which is now nearing completion, has been a difficult one. The subject is both complex and controversial. Some firms have used their own methods of recording for years, and because these methods were evolved separately in each organization, they are unlikely to have essential points in common. Others have never measured sickness absence. When industry realizes that the value of such records lies in their uniformity so that sickness rates for parts of an organization, and for different organizations engaged on the same type of work, can be statistically comparable, many of the difficulties in sickness recording will disappear.

The Board's investigators have made various studies of absence from work in Government and private industries. Some of the reports have not been published for security reasons; but all have shown the extreme variability of the amount of absence of which sickness was the most important single cause. In one investigation which covered 52 factories, the rates varied from 5 to 17 per cent. for men and 9 to 29 per cent. for women. The reasons for this variability were many; but in general absence was related to length and distribution of the working week, transport arrangements, supplies of materials and the attitude of the management towards workers. Where these factors were favourable to the worker, absence from all causes was less.

Methods of payment are also reflected in the worker's attitude to his work. A short investigation in one factory (Davis, 1944) showed that gastric disorders and discontentment with work were more frequent among women paid by the individual bonus method than in those paid on a group bonus system. The desire for some measure of security and for communal effort and reward was made manifest in this factory by a spontaneous and unauthorized sharing of wages.

A short study of the absenteeism among women in two factories (Wyatt, Marriott and Hughes, 1943) showed that contrary to general belief few women habitually lost one or more shifts each week, but a large majority were absent for varying lengths of time at irregular intervals. This suggests the need for a study of the personal causes of absenteeism. Further investigations into the amount, distribution and causes of sickness absence among women, which it is hoped to publish at a later date, have just been completed.

Hours of Work and Output. As previously mentioned, the urgent need for maximum output during the last war first brought the Board into being. And since then the Board's investigators have used variations in output as a criterion of efficiency and as a means by which to judge the optimum length of the working week and conditions of work. In a recent investigation, stable operations were selected for assessing the effect of a reduction in hours of work on output in several munition factories. The most striking feature of the output records obtained was the variability which was caused by (*a*) change in the design of product, (*b*) mechanical difficulties and machine breakdowns, (*c*) variations in the quantity and quality of the material used, (*d*) progressive improvements in the methods and conditions of work, (*e*) changes in the type and layout of machines, (*f*) dissatisfaction with the method and rate of payment, and (*g*) occasional friction between management and workers (Wyatt, *et al.* 1944).

In three groups which were fairly free from disturbing influences, the period after the reduction in hours, varying between 3·3 and 11·5 per cent., showed an increase in hourly output of 3·3 to 6·3 per cent. And the shorter working week was appreciated by the workers. This study illustrated the difficulty of trying to determine the relation between hours of work and output under war-time conditions.

Rotation of Night Shifts. The Board has had inquiries as to whether day and night shifts should be rotated weekly, fortnightly or monthly, or longer. Investigators in the last war gave evidence in favour of the weekly change, but present-day opinion is inclined to favour a longer interval between changes. There is obviously need for further research work in this field for which it is hoped that the Board will be able to obtain the necessary facilities. Here again output is a valuable criterion, and if it is to be used, the many other factors which affect it must as far as possible be eliminated.

Environmental Conditions. A great deal of unpublished work has been done on the ventilation and atmospheric pollution in filling factories and its relation to industrial sickness. New methods of sampling for airborne T.N.T. and other explosives have been used.

Much of the field work on lighting problems has been advisory, as the immediate need is to apply the results of previous researches. A report cover-

ing the work already done on lighting and the conclusions reached from experience gained during the war is being prepared.

Accidents. Researches are being undertaken in coalmines and factories on the incidence of accidents in relation to occupation, environment, the length and arrangement of hours of work and also training. The object of this work, which will include further studies on accident proneness, is to gain knowledge which can lead to a reduction in the rate of industrial accidents, already much too high.

Vocational Methods. Work now in progress consists mainly of introducing intelligence tests and tests of specific aptitudes into engineering factories as an aid to the selection and allocation of new workers. The aims are twofold: (1) to establish on a firmer basis the validity of vocational tests, both general and specific, and (2) to bring about an improvement in efficiency measurable in terms of increased production, as well as a decrease in transfers, dismissals, and personal friction. Most of the tests used have been designed by the Board's investigators.

Neurosis among Industrial Workers. The objects of this investigation are to find out the proportion of people among groups of industrial workers suffering from neurotic illness and the severity of such illness, and to see if there is any evidence as to its cause. It is too early to give results, but it can be said that the findings in one organization show that neurotic illnesses are responsible for a substantial proportion of lost time in industry. Naturally where, as in the case of this investigation, a psychiatrist makes the assessment on the results of a 30-minute interview and data obtained from a social worker, the incidence will be higher than that indicated by an analysis of causes of sickness absence using the panel doctor's certificate as a criterion.

Industrial Diseases. In the new Department for Research in Industrial Medicine at the London Hospital investigations have already been started on a number of problems, including the effects of exposure to duralumin dust and to dust arising from sugar-cane crushing (bagassosis); on the health hazards in foundries; on those associated with the use of compressed air in vibrating tools; and on the effect of exposure of workers to solvents used in the manufacture of aircraft.

Work undertaken by the Medical Research Council, with the collaboration of the Board and the Factory Department of the Ministry of Labour, includes investigations into the toxicity of the vapour of methyl alcohol, the hazards of welding, and dust in flax factories. There are others which cannot be mentioned here for security reasons.

Publications. In the past, the Board's reports have been published as scientific records of the results of research. These will always be necessary; but there is a need for publications written in non-technical language which can be readily understood by busy directors, works managers, workers' representatives and the workers themselves. A wider knowledge by all concerned of the results of research can lead to a better understanding of the action needed to improve conditions of factory life. With this view in mind, the Board started a new series of pamphlets. Two reports entitled 'Heating and Ventilation: Lighting and Seeing' (I.H.R.B., 1943) and 'Absence from Work: Prevention of Fatigue' (I.H.R.B., 1944) have already been published in this series. Their popularity, both at home and abroad, has proved their need. It is therefore proposed that in future the results of important new research shall be published both in a detailed scientific report as well as in a short, non-technical form.

IV. The Future of Industrial Health Research

In war time there is surely a need for research, particularly short-term investigations designed to produce quick results, which, if applied, will assist production by increasing the health and efficiency of workers.

But what about after the war? Will there still be the same need for research? The post-war reorganization of industry and demobilization will certainly demand the placement of both fit and disabled into jobs for which they are physically and psychologically suited. When this is done there will still be other problems only too obvious to the research worker. Industry includes a wide variety of different processes in diverse fields such as the factory, mine, warehouse, ship, railroad and office. In the factory, in particular, some of the minimum requirements for keeping workers healthy are laid down in the Factories Act, 1937. Although the principles outlined in this Act and elsewhere may have a general application to industries other than factories, more attention will have to be given to health problems which exist in almost unexplored fields—particularly shipping and other forms of transport. New problems not yet anticipated will arise in many processes since changes in methods of production are continually taking place.

A few possible subjects for future research are given below:

Heating and Ventilation

- Methods of cooling buildings in hot weather.
- The optimum method of using overhead unit heaters in factories, from the point of view of workers' comfort.
- Comfort in relation to thermal environment.
  - Investigations already done could be extended to cover higher temperatures and higher humidities.
- Physiological effects of work at high temperatures.

Atmospheric Pollution

- A study of comparative efficiencies of dust-sampling instruments.
- Continuation of investigations into atmospheric pollution by dusts in coalmines and factories.

Lighting and Vision

- Methods of improving lighting in coalmines.
- Better methods of lighting offices and places of employment other than factories.

Exploration of means of gauging sufficient and suitable lighting.
Lighting requirements for the partially sighted.
Effects of conditions of lighting on the rate of acquiring visual skills.

Job Analysis and Methods of Work

Physical requirements for various occupations, with particular reference to the type of jobs which can be suitably undertaken by the disabled and adolescent worker.
Design of machinery in the interests of the comfort and efficiency of the worker.
A study of various methods of work to prevent unnecessary strains and risks.

Industrial Psychology

Investigations into the validity of existing methods of assessment of qualities required for positions of authority (e.g. foremanship) and the possibility of developing objective methods.
Individual and group influences on efficiency and satisfaction with work.
A comparative study of different systems of payment and their relation to strain, satisfaction and efficiency.

Industrial Sickness

An analysis of morbidity rates in various industries and industrial regions. (Such an analysis should in itself provide problems for research).

Practically all the above subjects are related to the general health of workers. The promotion of general health in industry is a much bigger issue than the prevention of specific industrial disease which accounts for but a fraction of the sickness and disability suffered by the working population. Nevertheless industrial diseases do exist, and in aiming at their prevention there are now many opportunities for further research, and there will be more in the future as new processes with toxicological hazards come into being.

But the contribution which research into all problems affecting the well-being of workers can make towards the achievement of maximum health depends not only on the inspiration of the research worker but also on whether or not the results of his researches are applied. And for a wider application of existing and future knowledge we must look to the efforts of Government departments and industry, which latter includes management, industrial medical officers, and the workers themselves.

Acknowledgments

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HEALTH HAZARDS OF COAL-MINING

BY

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From the point of view of the industrial medical officer coal-mining is a rich and interesting source of study offering a variety of medical and surgical problems, which, if they are to be solved satisfactorily, must all be tackled in their natural setting. Medical questions involving illumination, ventilation, temperature, dustiness, posture and movements during work, can be weighed only by careful observation of the working place itself, and by talking there to the men. The difficulties of attending an injured man and transporting him outbye to the surface can be appreciated only by those who have helped to do it.

There is no industry which has had to suffer gladly the views of the uninformed as much as the coal-mining industry. These people, occasionally fortified by an underground visit, have not hesitated to state their opinions on the effect of undergound conditions on the health of the miner. In time of peace these views, which calmly ignore the efforts made to combat the industrial diseases of mining, the causes of accidents and the difficulties and successes met with, are of passing interest, but in time of war their effect has proved serious. The result is that the general community has come to regard the entry of young men into mining as a horror hardly less vivid than that of a dangerous military operation and quite devoid of the glory of military service. This attitude, which is as misleading as it is fantastic, has added greatly to the difficulties of obtaining willing man-power to work in the mines.

Working conditions below ground have been less affected by the war than other industries on the surface. Blackout has not interfered with ventilation, nor have workers been exposed to the risk of tuberculosis due to overcrowding and the entry of tuberculous patients. Arrangements are being made for strict clinical examination of all new entrants, and in South Wales radiological examination is also to be used.

Far be it from me to suggest that working underground in a mine is not ' war work ' or a ' man's job "—indeed it is so much so that a youth brought up in other spheres of life may well be proud of having done it. No two mines are alike ; they vary in size, some employing less than 10, others 3,000 and in a few cases even more. The depths range from several feet to well over 1,000 yards and the distances inbye to the working places may be from two to three or more miles, sometimes extending under the sea. In a few deep mines wet bulb temperatures reach and exceed 85° F. but this is exceptional.

In 1939, 1,955 mines were working and they produced over 231 million tons of coal. The average number of persons employed was 759,921, of whom 13,460 were boys under 16 and 2,320 were females. Approximately five times as many persons work underground as on the surface.

Women and girls, when employed (see Fig. 1),

FIG. 1.—Scottish pit girls.

mostly work on the screens sorting ' rubbish ' from the coal as it passes along the screening belts—a job which they do carefully. Their employment underground in this country has been prohibited since 1842 ; but it was not until 1935 that underground working by women was universally prohibited by an International Convention at Geneva. Special rules have been made to govern wash-places, mess-rooms, and sanitary conveniences. At some mines the girls have their own up-to-date shower baths and rest lounges. Minor injuries are usually dealt with by a senior girl who has some first-aid training ; more serious injuries, which are rare, are dealt with at the

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ambulance room of the mine. In this case a girl is always accompanied by a friend.

Mining hazards fall into two groups : accidents and industrial diseases. In both groups the whole-hearted co-operation of employer and employee is necessary in order that the risks may be reduced.

Accidents

The accident rate in mines is high, both for fatal and non-fatal cases ; mines medical officers, even more than other industrial medical officers, should therefore be familiar with the fundamental principles of early accident treatment. One of the main duties of the newly established Mines Medical Service is to advise on and encourage the most efficient first-aid organization both undergound and on the surface, and follow this up by taking an active interest in modern schemes of accident rehabilitation.* The value of efficient early treatment at the mine cannot be overstressed. The highest proportion of underground accidents are caused by falls of roof and sides and they occur at or near the coal face. The patient therefore must often depend upon the services of his comrades for the immediate treatment of his injury. We thus find that in every mine a large body of men have studied the subject of first aid with the sole purpose of helping their mates in case of accident. Quite apart from the bravery which is shown in difficult situations, the standard of work is often high. It is by no means unusual for a doctor at the mine, or for the surgeon who receives the case at hospital, to comment favourably on the excellent manner in which a fracture has been put up.

All types of fracture are met with and long stretcher journeys over uneven roads are often necessary. A clear understanding of the significance of shock is of primary importance. At a number of mines specially selected and trained ambulance men are allowed to administer morphine from ampoule-syringes ; this use of morphine however is strictly controlled.

In addition to first-aid men who deal with accidents in ordinary circumstances, there are Rescue Corps and Rescue Brigades. The men who form these units must be physically fit and specially trained for heavy work underground. They wear self-contained breathing apparatus. One of their main tasks is to enter and explore parts of the mine where it would be dangerous for other men to go, either because of the possible presence of carbon monoxide or because the percentage of oxygen is low. In the past the most dreaded hazards of the miners' calling were explosions, and sometimes underground fires from spontaneous combustion, but these occurrences are now happily much less common, and when they do occur they are usually of smaller dimensions. An explosion is usually due to ignition of 'firedamp' the chief constituent of which is methane —CH_4. This gas explodes when it is mixed with air at percentages ranging between 5 and 13 approximately. The explosion may then be propagated along roadways by the combustion of fine coal-dust which is raised by the force of the explosion. The medical results of an explosion include burns, injuries due to violence, and asphyxia from the carbon monoxide of the 'afterdamp.' Experience has brought out two vital points in treatment: (*a*) every effort should be made to prevent a man who is suffering from burns, even if these seem to be of small degree, from walking outbye; (*b*) a mixture of 93 per cent. oxygen and 7 per cent carbon dioxide should be administered as soon as possible in order to hasten the dissociation of carbon monoxide from the haemoglobin. The possibility of these disasters gives further emphasis to the value of efficiently trained ambulance men and the importance of a liberal supply of first-aid requisites in the mine.

Existing statutory first-aid requirements include three main provisions: (*a*) arrangements below ground extending to the working face—these consist in the provision of sterilized mine dressings, splints, and stretchers; (*b*) a properly equipped and staffed first-aid room on the surface—the man in charge of this room should be specially trained in casualty work, and the appointment of an industrially trained female nurse for the supervision of this part of the organization has much to recommend it; (*c*) facilities for transporting the patient promptly by motor ambulance from the mine to his home or to hospital.

Industrial Diseases

Industrial diseases in the mining industry form an impressive list and their prevention calls for continued study. It is worth noting that all mining industrial diseases are to a greater or less extent preventable. Just before the war the incidence of these diseases, with the notable exception of pneumokoniosis, was tending to fall; on the other hand, spirochaetal jaundice (Weil's disease) was insidiously making its appearance.

It may be of interest to enumerate and briefly describe the diseases for which compensation is payable to those who are disabled. In the year 1939, when 759,921 persons were employed, the percentage of cases for which certificates of disablement were given is noted in Table 1.

* Rehabilitation Centres for miners are now established in the various coalfields. These centres are controlled by a Rehabilitation Advisory Committee under the chairmanship of Mr. R. Watson-Jones. This committee was set up by the Miners' Welfare Commission.

TABLE 1

CASES IN WHICH CERTIFICATES OF DISABLEMENT WERE GIVEN IN 1939

Silicosis (New cases [1])	Nystagmus	Beat hand	Beat knee	Beat elbow	Inflammation of wrist	Dermatitis
0·06 per cent. (465)	0·147 per cent. (1033)	0·13 per cent. (980)	0·56 per cent. (4276)	0·09 per cent. (721)	0·05 per cent. (406)	0·04 per cent. (305)

N.B. The figures in brackets represent the actual number of cases.

[1] This does not include death certificates granted to men who have previously been certified as disabled.

Miners' Nystagmus. Much remains to be determined about miners' nystagmus. It would seem to be an affection of the nervous system, the most marked sign of which is a rotary oscillation of the eyeballs. Behind this physical sign, which itself is not finally accounted for, lie hidden a series of even less understood ' nervous ' symptoms. These range from headache, insomnia, and photophobia to marked mental depression. Indeed it is mental depression which is the main cause of disablement, for on careful examination many workmen who are quite unaware of it show oscillation of the eyeballs.

As to the cause, I agree with the conclusion of the Third Report of the Miners' Nystagmus Committee (Medical Research Council 1932) which is stated thus:—' The present Committee, however, have seen no evidence or criticism which would entitle them to withdraw from the conclusion arrived at by the first Committee, viz., that the fundamental cause of miners' nystagmus in the narrower sense of the term (i.e. oscillation of the eyes) is the low illumination under which miners in general work.'

The effect of low illumination on the eye is that the function of the retina is maintained by the peripheral field; in other words the central part of the retina—which is composed only of cones, is associated with acute vision, and needs good light—is thrown out of action ; vision is taken over by the larger, but less acute, peripheral part of the retina, composed mostly of rods which function in conditions of poor illumination. Oscillation of the eyeball arises in order that the image shall be thrown on the peripheral part of the retina. In order to avoid this change-over from central to peripheral vision, a minimum standard of light for safety lamps has been specified in the Coal Mines Regulations (Lighting) 1934.

It is essential that the desired standard of illumination should be kept up *throughout the working shift*. A hint as to the nature and cause of the ' nervous ' manifestations is contained in a note on treatment, by the same Committee, which states ' The Committee are strongly of opinion that the practical treatment of the disease . . . should consist in the elimination of a hopeless dependence on compensation, by the provision of opportunities for work of some kind, the end in view being complete restoration to full work underground, under conditions of proper illumination, even if this has to be preceded by a period of work in daylight.' An aid to better illumination is also provided for by regulations which require certain parts of the mine (where the total number of persons employed exceeds ten) to be effectively whitewashed.

Pneumokoniosis. The presence of this disease in South Wales has recently excited much interest and led to an extensive investigation. Just as in South African gold mines several years passed before the existence and cause of pulmonary fibrosis (in this case, silicosis) was recognized and subsequently dealt with, so in South Wales as time went on a new type of x-ray picture began to be observed. Silicosis, by which is understood a type of pneumokoniosis characterized by nodular fibrosis, had already been acknowledged, and compensation schemes were drafted to meet the liability. The disease was diagnosed among men who bored in siliceous strata, such as Greys in Somerset and Pennant in South Wales. Cases were, however, coming forward for examination which, although showing various degrees of disablement, did not conform to the standard required for the condition designated as silicosis owing to the absence of nodulation. This led to the—now well known—Medical Research Council's exhaustive investigation of 1936.

This investigation showed that cases of lung fibrosis occurred among colliers who had never worked in rock with boring machines. The x-ray picture of a large proportion of these men showed a fibrotic network to which the name ' reticulation ' is given. The recognition of this fact led to a widening of the compensation term from silicosis to pneumokoniosis so that this form of dust fibrosis was

FIG. 2.—Nystagmus Patient, showing ' Tilt of the Head ' (Photophobia).
(By kind permission of Dr. T. Lister Llewellyn.)

FIG. 3.—Reticulation. Man aged 39 years. 21 years underground, South Wales, haulier and collier.

included as well as silicosis. In coal-miners' lungs where there is nodulation or consolidation there is mostly reticulation, but reticulation can, and in a great many cases does, exist without either nodulation or consolidation. Moreover, there is no

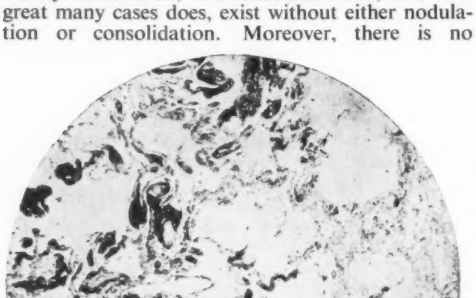

FIG. 4.—Collier. 36 years. Emphysema around coal nodules.

(By kind permission of Dr. Gough.)

definite evidence that reticulation must inevitably lead to nodulation or consolidation, but it would seem that it may do so particularly if the man goes on breathing harmful dust, and the more dust he breathes the more likely it is that reticulation will develop.

One of the most constant symptoms of pneumokoniosis among coal-miners is dyspnoea. Further clinical study is necessary in order to determine the exact cause of the dyspnoea. It has been noted that marked pulmonary emphysema is a common sequel to fibrosis, and Dr. J. Gough of Cardiff has demonstrated to me a fine type of emphysema in and

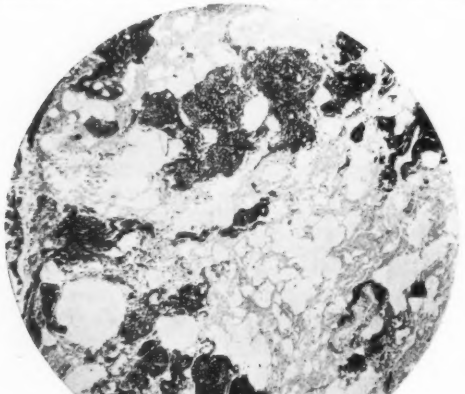

FIG. 5.—Collier. 39 years. Emphysema around coal nodules.

(By kind permission of Dr. Gough).

around the 'coal nodule' which in his opinion is closely connected with dyspnoea. This condition will doubtless be described in detail by Dr. Gough when he has completed his pathological research work.

So far as present knowledge goes the incidence of the disease amohg colliers is confined to South Wales; it is relatively low in the bituminous mines of the south-east of the coalfield but extends progressively higher to the anthracite mines of the north-west. It is noteworthy, however, that the incidence of pneumokoniosis is very low in some anthracite mines. Another point is that, even in 'high incidence' mines, a large proportion of workers do not develop abnormal fibrosis, whilst a large proportion do not seem to go beyond the stage of reticulation.

Much attention is being directed to prevention. Various methods of dust suppression are being experimented with and the results noted and correlated. It is hoped that facilities for long-term medical research will soon be provided which will include clinical, radiological, pathological and other branches of investigation.

Inflammatory Diseases of Hand, Knee, Elbow and Wrist. The diseases popularly known as 'beats' are compensable under the Workmen's Compensation Act, 1925, and are scheduled under the following descriptions: subcutaneous cellulitis of the hand (beat hand); subcutaneous cellulitis or acute bursitis arising at or about the knee (beat knee); over the elbow (beat elbow); inflammation of the synovial lining of the wrist-joint and tendon sheaths.

Mechanization at the coal face facilitates the working of thin seams in which workmen are particularly liable to develop the 'beat' diseases, and may be one of the causes of the rising incidence of beat knee and beat hand. Furthermore, during recent years, workmen have been strongly encouraged to take care of even minute abrasions and it may be that more cases are now being reported.

Beat Hand. This condition arises when the primary injury is caused by repeated jarring of the hand by the pick followed by the entry of pathogenic organisms. The infection may enter by the most minute abrasion, cut or crack in the skin. Hard manual labour usually makes the skin of the hands tough and resistant, but if the hands have become soft by a period of off work, and especially if the pick handle is rough or thick, injury is likely to follow. Experienced miners realize this and smooth their pick handles with a knife, emery paper or even a piece of glass. The pick should not be held too tightly, especially if the coal is very hard; much care should be taken to keep the pick handle free from gritty particles; and the workman should see that it is not splintered or split. If the skin of the hand has become soft it may be toughened by the application of spirit. Cuts or cracks on the palm of the hand should receive immediate and careful first-aid attention.

Beat Knee. In this case the inflammation is due to injury and subsequent infection caused by working for long periods in a kneeling position, or moving about and pivoting on the knees whilst shovelling. The first sign of the condition may be a pimple or pustule on the part of the knee which is longest in contact with the floor, but later on the whole knee may become involved. Cases of beat knee usually occur in men who work in seams between 3 feet 6

inches and 2 feet 6 inches in thickness ; in these circumstances special care should be taken. In seams of greater thickness kneeling can often be avoided, while in thinner seams the worker is constrained to lie on his side, i.e. his body is mainly supported by the elbow, hip and leg. The danger of infection is increased if the working place is wet because the skin of the knee becomes sodden. The hardness of the floor is also important. At one mine more cases occurred where the floor was of hard fireclay than where it was a carbonaceous shale.

Protection of the knees usually takes the form of knee-pads. Four types are used: (*a*) pads which are strapped to the leg; (*b*) pads which are sewn or fitted into the trousers; (*c*) several folds of stocking over the knee; and (*d*) small mats, usually of rubber, on which the miner can kneel when necessary.

These pads need not be very thick. The essential precaution is to prevent particles lodging between the skin and the inner surface of the pad, so the pads should be thoroughly freed from particles from time to time.

First-aid treatment of small scratches or cuts, especially if there is redness, swelling or pain about the knee, is important. Boils and pimples on the knee should receive early attention at the first-aid room. They should not be squeezed. Poultices should not be applied except on a doctor's instructions because they tend to cause spread of infection.

Beat Elbow. Beat elbow, like beat knee, is an acute inflammation affecting the subcutaneous tissues and the underlying bursa. It arises through using the elbow as a support whilst ' hand holing ' in a thin seam. It usually occurs in miners who work in seams thinner than those which are associated with cases of beat knee. Swelling and pain are noticed over the elbow.

Preventive measures consist in the use of elbow pads. Nothing elaborate is needed. The author has seen a simple mat made of several folds of thick material answer the purpose. As in the other ' beat ' conditions, it is essential to avoid rubbing small gritty particles into the skin. With all three conditions, beat hand, knee, and elbow, work should be suspended and a doctor consulted at the earliest sign of inflammation or pain of a throbbing character.

Synovitis of the Wrist. This is brought on by over-exertion and jarring of the wrist. The onset is usually accompanied by tenderness or pain on movement, together with swelling. The symptoms may clear up after a short rest, or the case may become chronic. The use of wrist straps, which used to be common, is now rare; they might be worth trying again, especially by men who have just recovered from the complaint, and are about to resume work. Their use reduces the excursion of tendon movement. The wrist straps should be padded and well-fitting but not fastened so tightly as to interfere with the blood supply to the hand. Again, small cuts or scratches on the hands, wrists, and forearm should be attended to in order to avoid infection.

Infective Jaundice. (Spirochaetal Jaundice: Spirochaetosis Icterohaemorrhagica: Weil's Disease.) This disease is caused by the micro-organism *leptospira icterohaemorrhagiae* found in rats. It has been notifiable in Scotland since 1924, but not in England and Wales. Nevertheless it has been recognized for some years in many countries. Compensation is now payable provided that the diagnosis is confirmed by bacteriological or serological examination. As far as the coal-mines of Great Britain are concerned cases have been reported in Scotland, North of England, and South Wales.

When investigating the disease among coal-miners, it has been noted that the presence of rats is nearly always established and the working places in the mines are wet. It has been shown, at certain mines where men who have contracted the disease have worked, that rats caught in the mines have harboured the leptospira, and in one case the organism was isolated from the jelly-like slime which clung to the timber. Moreover, the workings are usually shallow, and they nearly always communicate with the surface by a drift or level. This fact may be of importance, for not only may rats enter the mine, but they can easily leave it and go, for example, to a river, farm, or dwelling-house, and then return to the mine. Surface water, which may be contaminated, penetrates into shallow mines with comparative ease; for instance, a definite increase of water is sometimes noticeable at the time of a thaw following a heavy fall of snow. On the other hand rats are present in many mines, both shallow and wet, at which no cases of infective jaundice are known to have occurred.

Diagnosis.—Certain manifestations are usually associated with the disease, namely, fever of sudden onset, severe pain and muscular tenderness, congestion of the conjunctivae, jaundice, and haemorrhages under the skin and the mucous membranes. The disease may be fatal, or it may be so mild as to be missed owing to the absence of jaundice; in fact, blood specimens from a number of men working in the same part of a mine were found to be positive although some of the men had shown no clinical signs of the disease; the incubation period is said to average about ten days.

The diagnosis of the disease can be confirmed with some certainty by means of bacteriological or serological tests, and this confirmation is necessary to support a claim for compensation.

Transmission.—The organism may enter the body through abrasions in the skin, through the alimentary tract from contaminated food, or through the mucous membrane of the nose. One miner with whom I spoke attributed his attack to water which he had splashed up from the road in the mine into his face and mouth. As it is the general opinion that the disease is transmitted from rats to men, the first and most important preventive measure in mines is to rid them of rats. This matter is receiving attention with the collaboration of the Infestation Branch of the Ministry of Food.

Dermatitis. Dermatitis attributable to working conditions is less frequent than might be expected in an industry which is dusty and in which the workers are brought into contact with so many different objects. The factors which have been put forward as causes of dermatitis (A) and the preventive measures (B) which have been suggested are as follows:—

A	B
(*a*) Tinea pedis among users of pithead baths.	Thorough drying of feet after bathing. Dusting between toes with a powder, e.g. mixture of zinc oxide, boric acid and starch, swilling out of

A	B
	baths by an antiseptic solution, e.g. Izal, excluding workers affected from use of baths.
(*b*) Ringworm contracted from pit ponies.	Medical treatment of both pit ponies and persons affected.
(*c*) Strong acid or alkali solutions among lamp room attendants.	Possibly a 'barrier' substance; careful washing in running water.
(*d*) Grease and oils.	do.
(*e*) High wet-bulb temperatures (over 75° F.).	Improvement of ventilation if sluggish.
(*f*) Handling of wet cement (e.g. when sinking shafts).	Thorough washing and drying of hands and arms at end of each shift.
(*g*) Water rich in chlorides; on floor or from roof.	Measures determined by circumstances.

As many cases become disabled through secondary infection men with any type of skin lesion or abrasion are encouraged to make early use of the surface ambulance room at mines. A large proportion of cases must be due to non-industrial causes for it cannot be expected that miners are immune from skin diseases such as scabies, eczema, impetigo, and psoriasis.

High Temperature in Mines

The effect on workers of natural high temperatures in mines is largely one of economic importance, but it must also be considered from the point of view of health. Much work has been done on high temperatures in mines, but up to the present no enforceable standards of wet- and dry-bulb temperatures or of ventilation have been recommended.

The problem of fixing legal standards is difficult because several factors are interdependent. It is agreed that the dry-bulb temperature is of less importance than the wet-bulb temperature, because it is the continuous cooling of the skin by evaporation of sweat which is of significance.

It must be recognized that there is a fundamental difference between a man and a thermometer. For a given set of conditions a thermometer always gives the same result; but man has the power to adapt himself to environment—a phenomenon known as acclimatization. In hot mines this manifests itself by control of body temperature through increase in the amount of sweat given off, so that an acclimatized miner does not show the rise of body temperature which might occur in an unacclimatized man; he sweats sufficiently to allow his skin to remain comparatively cool by evaporation, provided that an adequate air current is available.

It may be observed that where men sweat in an atmosphere of high wet-bulb temperature, and where sluggish ventilation minimises the evaporation of sweat from their bodies, there is a tendency for men to develop skin rashes and boils. This is noticeable from 75° F. wet-bulb upwards. To render conditions in a hot mine as healthy and comfortable as possible, suitable limits of wet- and dry-bulb temperatures and rate of air current passing over the workers should still be sought. Heavy sweating and drinking large amounts of water may cause muscular fatigue and even severe cramp. Most men who are inconvenienced in this way can improve their condition by drinking less water and by adding a little salt (half a teaspoonful to a pint of water) in order to restore the normal chloride concentration. This is being done at some mines.

Mines Medical Service

It was in 1927 that the first Medical Inspector of Mines was appointed, but for some years it has been evident that a single medical officer stationed at headquarters could not be expected to cope with the many and varied problems peculiar to the coal-mining industry. The Mines Medical Service now consists of a Chief Medical Officer and Deputy Chief Medical Officer stationed at headquarters, and eight Mines Medical Officers stationed in the regions. It owes its origin to the White Paper on Coal (1942) which laid down that as part of the reorganization of the mining industry, and with a view to checking wastage of labour, there should be established a medical consultative service for the mines.

The mines medical officers have to survey the main hospital, clinic, and rehabilitation services used by coal miners, and make professional contacts with the organizations and doctors in charge—with the object of ensuring that the miners gain full value from hospitals and the Emergency Medical Service. For these purposes it is necessary for them to establish close relations with the local medical officers of the Ministry of Health. The effectiveness of this part of the work depends very largely on professional contacts and influence. A war-time addition to their duties is to act as a link between National Service Officers and Medical Referees in the case of men who apply to leave the industry on medical grounds.

It is hoped that this paper has indicated, although briefly, something of the various health hazards in this vitally important industry, and the problems with which the new medical service therefore has to deal. As time goes on its study of the preventive measures of mining industrial diseases will develop and will help to spread knowledge of special hazards and encourage the mining community to avail themselves fully of the facilities which are being provided to protect and rehabilitate the workmen. The service will thus become one of the many medical teams engaged in raising the general level of public health.

EFFECT OF ALUMINIUM AND ALUMINA ON THE LUNG IN GRINDERS OF DURALUMIN AEROPLANE PROPELLERS

BY

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M.R.C. Investigations in 1936

In 1936 the Industrial Pulmonary Disease Committee of the Medical Research Council investigated both clinically and radiologically a group of fifty workers who had been exposed for a number of years to the inhalation of alumina in the reduction factory of the British Aluminium Company. The results are shown in Table 1.

They also considered the sickness records of all the workers (Hill, 1936), as compared with those in other parts of the factory (Table 2).

The dust cloud consisted of alumina with small proportions of aluminium and sodium fluorides, sodium oxide, and cryolite. The number of particles per ccm. varied from 400 to 2430, and median sizes of particles over the whole series were between 0·23μ and 0·5μ. The Committee after reviewing these findings was unable to find any evidence that the inhalation of alumina dust had caused fibrosis of the lung.

Other Investigations

Denny, Robson, and Irwin (1937) successfully used 1 per cent. grease-free metallic aluminium powder of a particle-size below 5μ in the prevention of silicosis; and in 1939 they showed that on being converted into hydrated alumina it reduced the toxicity of quartz in tissues by flocculation, absorbing silica from solution, but chiefly by coating the quartz particle with an insoluble and impermeable coating which is gelatinous hydrated alumina. This on drying forms the crystalline alpha aluminium monohydrate ($Al_2O_3H_2O$). Dust inhalation experiments in animals showed that metallic aluminium

TABLE 1

Age group	No. of men examined	Years of work in furnace-room	*A* No changes clinically or radiologically	*B* Clinical and x-ray changes *	*C* Clinical changes †	*D* Radiological changes ‡
20–29	6	6–12	3			3
30–39	12	6–18	7		1	4
40–49	10	11–25	5	3		2
50–59	14	14–34	9	1		4
60–69	8	12–39	6	1		1
Total ..	50	6–39	30	5	1	14

TABLE 2

NUMBER OF SICKNESSES RECORDED UNDER GIVEN DIAGNOSES

Diagnosis	Reduction Works	Other Parts of Factory
Diseases of respiratory system	42 (31·1 per cent.)	59 (43·7 per cent.)
,, digestive system	8 (5·9 ,,)	12 (8·9 ,,)
Rheumatism, etc.	13 (9·6 ,,)	6 (4·4 ,,)
Infectious diseases	5 (5·7 ,,)	1 (0·7 ,,)
Injuries	31 (23·0 ,,)	23 (17·0 ,,)
Skin conditions	7 (5·2 ,,)	7 (5·2 ,,)
Other causes	15 (11·1 ,,)	16 (11·9 ,,)
No diagnosis	14 (10·4 ,,)	11 (8·2 ,,)
Total	135 (100·0 per cent.)	135 (100·0 per cent.)

* Previous pneumonia, asthma, catarrh, chronic bronchitis, fibrosis.
† Bronchial catarrh.
‡ Slightly increased stratum 3, evidence of old pleurisy 3, slight emphysema 4, calcified glands 2, catarrh 2.

alone produced no fibrosis or other significant pulmonary reaction. Eight rabbits were exposed to an atmosphere containing freshly ground finely particulate aluminium powder in a concentration averaging 7000 particles per cc. 12 hours daily for 14 months. Following the cessation of the dust exposure some of the animals were observed for a further seven months. Chemical assays of the lungs showed them to contain from 270 to 1200 mg. of aluminium per 100 g. of dried tissue. During their lifetime these animals gained normally in weight, and from the appearance and texture of the fur and their general behaviour there was no evidence of any harmful effect due to the inhalation of the aluminium dust.

The lungs showed a uniform dark mottling of the pleural surfaces and on sectioning this was seen to be distributed uniformly throughout. Microscopically the mottled areas were shown to be aggregates of dust cells almost completely filling adjacent alveolar spaces. These cells contained irregular shaped opaque particles, the majority being under 3μ in diameter. Practically all these particles were present in the dust cells. These cells presented regular outlines and their nuclei stained well. The alveolar walls throughout the lung showed no evidence of thickening except occasionally in the dust-containing areas. This thickening consisted of a slight alveolar endothelial proliferation. The ciliated epithelial lining of the bronchial tree appeared normal. The lymphatic spaces and aggregates throughout the lung contained relatively few dust-laden cells, and showed no evidence of thickening or damage.

Goralewski (1943) has described symptoms arising in aluminium workers in Germany. He investigated 700 workers exposed to metallic aluminium and made vital capacity and sputum tests on 125 and blood counts and sedimentation rates on 100. These workers complained of dry cough with pain on breathing, shortness of breath, poor appetite, and gnawing abdominal pain. Spontaneous pneumothroax developed in four instances (1941). They were making aluminium powder; 1 gr. aluminium powder contains about four milliards of particles of dust, but no account is given of the environmental conditions in which the men worked. The chemical composition, concentration and particle-size of the dust in the atmosphere is not stated. No abnormal physical signs are described. The blood counts showed normal white cells with a relative lymphocytosis and an eosinophilia of up to 10 per cent. The sedimentation rate was within normal limits in 78 per cent. of the cases. The vital capacity was decreased in 27 instances. The x-ray appearances consisted of focal shadows in the apical regions with an increase of normal bronchial markings in the upper and middle thirds of the lung giving a reticular appearance. There was sometimes an increase in these markings in the lower lobes, suggesting increased drainage to the hilar glands. Retraction of the diaphragm and distortion of the heart shadow were found. At a later stage the focal shadows tend to increase and become confluent. Definite changes were found amongst 24 of the first 125 cases (1940). The development of the illness is rapid and appears to bear no relation to the length of exposure. It may develop in as short a period as nine months.

One patient died, and histological examination of the lungs after necropsy revealed coarse branching hyaline collagenous fibres, enclosing phagocytes containing fine and coarsely granular particles which differed from carbon particles by their jagged outlines. In parts of the lung these hyaline collagenous fibres were found surrounding the walls of the alveoli, which contained phagocytes. The changes were most marked in the right upper lobe. The regional lymph glands exhibited a few of these dust cells lying chiefly in small groups. These histological changes, he suggested, result from a colloidal reaction between aluminium dust particles and the tissue fluids.

According to Jäger and Jäger (1941) the statements of Goralewski are supported by their practical experimental work. These authors point out that while aluminium powder is highly resistant to aerial oxidation and to water, it is freely soluble in sodium chloride solutions (with the evolution of hydrogen). The resulting solution contains aluminium chloride and sodium aluminate in a condition of equilibrium, and if the sodium and chloride ions are allowed to diffuse away, then a colloidal aluminium hydroxide complex results. They state that if this reaction with aluminium powder is allowed to take place in biological media, which contains protein as well as sodium chloride, then the protein is ' tanned ' and is co-precipitated with the aluminium hydroxide complex round the partly dissolved aluminium particle. This system is said to be highly resistant to solution and phagocytosis, and if it takes place in the lung tissue then results in the clinical condition which Goralewski calls ' aluminium lung.' Histological evidence is brought forward in support of the above contention, and the theory is extended to explain the good effect reported of the use of aluminium powder in the prevention of silicosis.

Koelsch (1942) reviewed this experience with 150 workers. He believed, however, that mechanical factors were primarily responsible for the changes and that unsatisfactory ventilation of industrial workrooms because of black-out rules was to a large extent responsible. This seems to us a more reasonable explanation, and possibly has a bearing on the discrepancy with our investigation.

Evang (1938) in Norway, Riedl (1939) in Czechoslovakia, and Cotter (1943) in the United States have described cases of bronchial asthma following exposure to aluminium. However, the fact that so few cases have been reported indicates that very few people show sensitivity to this metal.

Present Investigation

In view of the definite findings by German workers it was decided that a thorough investigation was needed of the health of aeroplane propeller grinders

in England, especially as several of them were complaining of respiratory symptoms. During this war Duralumin, which is an alloy of 95 per cent. aluminium, 3·5 to 4·5 per cent. copper, 0·4 to 0·7 per cent. manganese and 0·4 to 0·8 per cent. magnesium, not more than 0·7 per cent. silicon, 0·7 per cent. iron, and 0·3 per cent. titanium, has been used for making aircraft propellers. These propellers are ground smooth with alundum wheels (calined aluminium oxide 95 to 97 per cent., ferric oxide 0·3 to 0·6 per cent., titanium oxide 2·2 to 2·8 per cent., and silica 0·2 to 0·4 per cent.). This process creates much dust and despite good ventilation the workers become covered with the dust and assume an aluminium colour as will be seen in the illustrations (Plate I).

Factory Conditions. A comprehensive study of the environmental conditions has been carried out in the particular factory under review. The factory building consists of a rectangular construction 120 ft. × 68 ft. × 17 ft. high. It has a dual ventilation system, first dealing with the general atmosphere, and secondly fitted to individual benches where the dust is extracted as produced. The general atmosphere ventilation ensures eighteen air changes per hour. The individual ventilation operates through a slatted bench below the worker and aims at withdrawing downwards the aluminium particles. The air-change capacity at each bench rated in velocity of each fan per unit is 1660 cubic feet per minute.

The shop is divided mainly into two parts, one concerned with cutting and the other with finishing. The cutting tools produce large aluminium shavings and no dust. Finishing is divided into two processes, grinding and polishing. Grinding is carried out by means of a rotating disc faced with an alundum abrasive paper. The disc is driven by a flexible drive and hand directed. The disc is pressed on to the aluminium and the fine particles are thrown in a horizontal direction, the bulk being carried away through the slats of the bench by the ventilation system (Fig. 1). Four different grades of abrasive disc are used, beginning with a very coarse paper, and becoming progressively finer. The size of the aluminium particle cut away is thus dependant upon the fineness of the abrasive. Polishing is carried out by means of a buffer wheel also with flexible drive and hand directed. The buffer wheel is of the multiple-linen disc type and is edged with a composition of alundum and adhesive which is allowed to dry before use. The particles are very much finer than those obtained by the grinding process, and since the throw is mainly in a vertical direction the scatter of particles is greater than with any other process.

Physical Analyses. Measurement of the atmosphere content of aluminium has been found by chemical estimation, and assessment of the particle size by means of the thermal precipitator. Chemical sampling is carried out by suction of a known volume of air through a paper filter fixed into an ebonite cone. This is maintained at the operator's mouth level during sampling. The aluminium is extracted from the paper by dilute acid and estimated gravimetrically with 8-hydroxy quinoline if the sample is sufficiently large, or colorimetrically as the lake with aurin carboxylic acid if micro quantities are involved. The colorimetric method of Front and Kirsner (1942) adapted for use with the Spekker photo-electric absorptiometer has been used in this connection.

The following results have been obtained with sampling at the various points in the factory, and represent the average of a number of determinations made at different times.

Grinding Process.—The average concentration of aluminium in the atmosphere close to the operator's mouth as measured chemically in the manner described above is of the order of 3–5 mgs./m³. The bulk of this consists of large particles of aluminium made up as follows :—

Particles 7μ and upwards (less than 1 per c.c.) $=2$ mg./m³

„ 2–7μ (6 particles per c.c.) $=1$ mg./m³

The light fraction has been collected and examined by the thermal precipitator technique and has been shown to exist almost exclusively of transparent particles less than 1μ. This must therefore be composed of the aluminium oxide abrasive. The number of particles per c.c. is about 5200 of which

3325/c.c.	$<0{\cdot}2\mu$	$\equiv 0{\cdot}03$ mg./m³
1750/c.c.	between $0{\cdot}2\mu$ and $0/4\mu$	$\equiv 0{\cdot}16$ „
125/c.c.	„ $0{\cdot}4\mu$ and $0{\cdot}8\mu$	$\equiv 0{\cdot}05$ „
	Total ..	0·24 „

At the polishing bench the amount of dust present at operative level is of the order of 50 to 100 mg./m³, depending on the direction of the buffing wheel. This consists almost exclusively of large aluminium particles, but with a significant fine fraction again transparent in appearance and therefore obtained from the alundum abrasive.

The distribution is as follows :—

Coarse Fraction.—

Particles 7–40μ (12 particles/c.c.) $\equiv 95$ mg./m³

„ 2–7μ (8 particles/c.c.) $\equiv 1{\cdot}4$ „

Fine Fraction.—(Mainly transparent.)

3000 particles per c.c. less than 2μ

comprised or 1600/c.c.	$<0{\cdot}4\mu$	$\equiv 0{\cdot}2$ mg./m³
1150/c.c.	$0{\cdot}4$–$0{\cdot}8\mu$	$\equiv 0{\cdot}5$ „
350/c.c.	$0{\cdot}8$–2μ	$\equiv 2{\cdot}0$ „
	Total ..	2·7 „

In addition to these sampling points, an investigation was made of the content of the general atmosphere in the shop. Positions were taken at least 10 ft. from any operator. The result showed that the aluminium dust had settled out by reason of its gross particle size, but that there was a persistent concentration of the very fine transparent fraction of aluminium oxide.

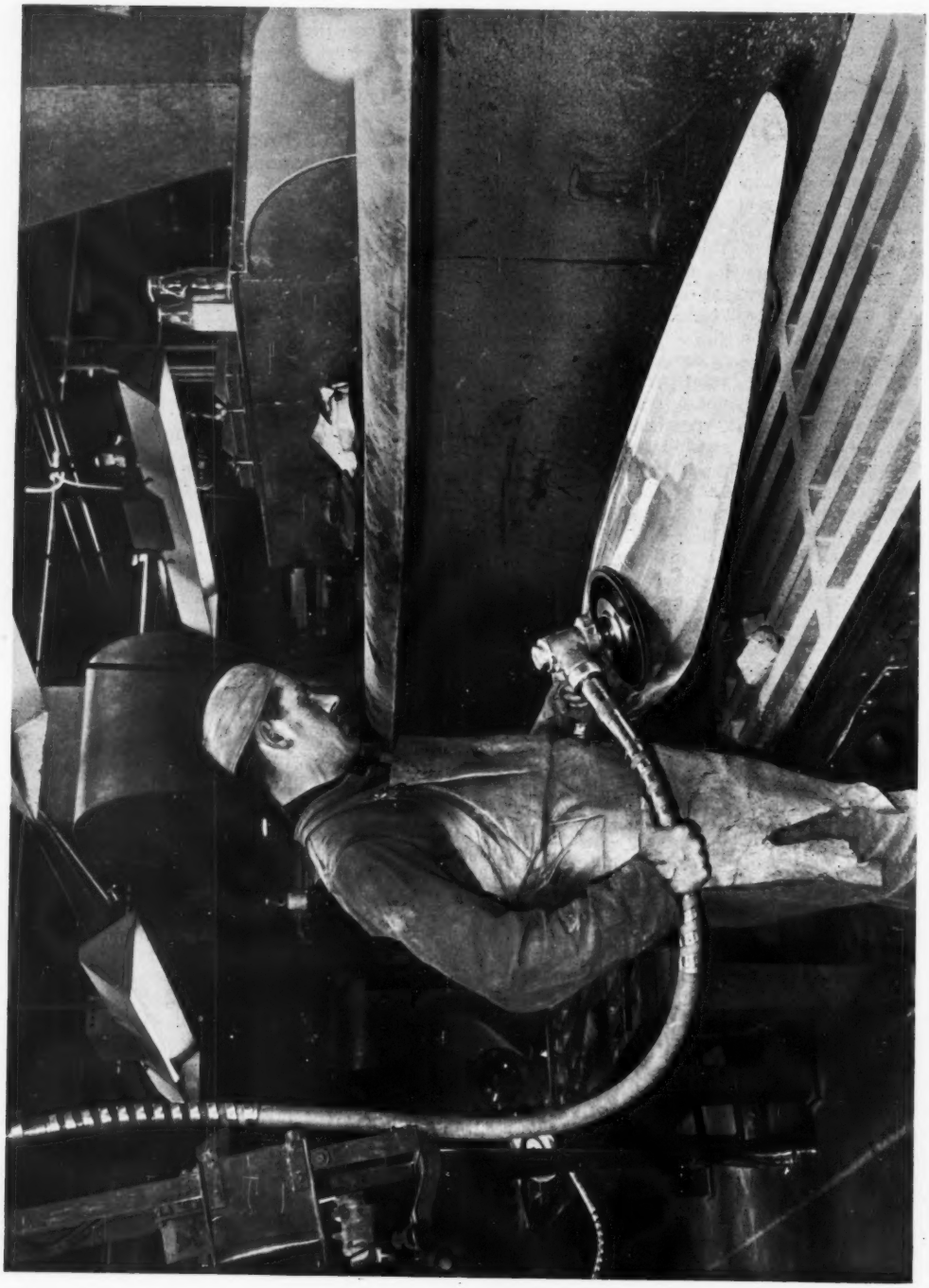
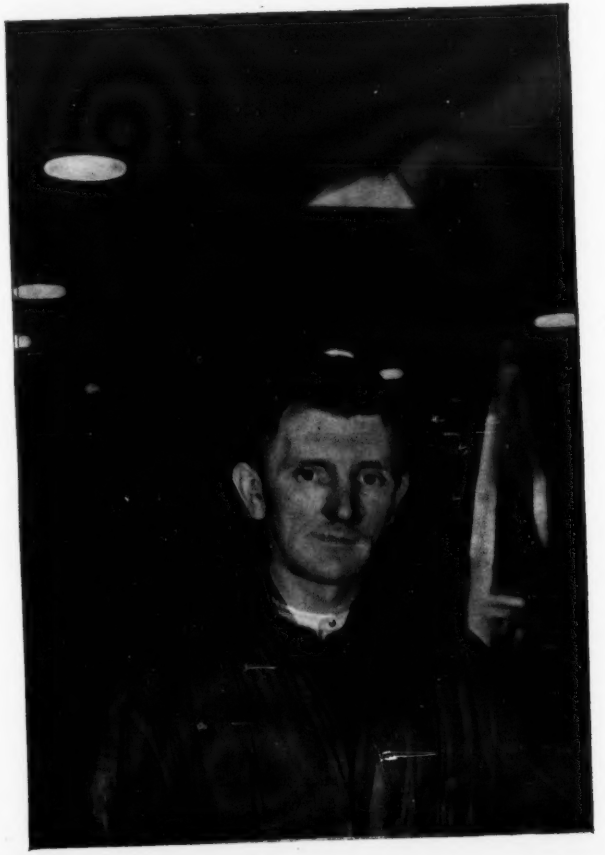


FIG. 1.—Duralumin propeller grinder at work.

FIG. 1.—Duralumin propeller grinder at work.

Dust seen on man's hands, face and clothing and ventilation slats of bench.



Dust seen on man's face, particularly on upper lip.

PLATE I

(By courtesy of C. Martin Sharp, Esq.)

All particles were less than 1μ and were about 2500 per c.c.

2000 per c.c.	less than 0·2μ	≡0·02 mg./m³	
425 ,,	between 0·2μ and 0·4μ	≡0·04	,,
75 ,,	,, 0·4μ and 0·8μ	≡0·03	,,
	Total	0·09	,,

It is reasonable to assume from these results that the softer duralumin metal is cut by the hard abrasive forming gross particles which readily settle out and which stand a good chance of being trapped by the nose and upper respiratory passages of the operator.

Examination of the general air, however, suggests that very stable concentrations of finely dispersed aluminium oxide abrasive of concentration of the order of 0·1 mg./m³ are constantly present despite the ventilation changes. These values are higher nearer to the grinder (0·24 mg./m³), and much higher proximal to the polisher (2·7 mg./m³). Such particles may conceivably be breathed deeply into the lungs.

Clinical Findings. All the grinders and polishers of propellers in one factory were interviewed and their occupational histories were taken. Twenty-seven claimed to have some cough, and ten to be somewhat short of breath, but these symptoms did not appear to cause them inconvenience.

Sick Records.—The sick records of the group were examined and compared with a similar group of workers in a machine shop belonging to the same company. This analysis showed no difference of statistical significance between the two groups. It was as follows (Table 3) :

TABLE 3

NUMBER OF SICKNESSES RECORDED UNDER GIVEN DIAGNOSIS DURING THE YEAR 1943

Diagnosis	Aluminium propeller grinders (97)	Machine shop workers (100)
Diseases of respiratory tract, coryza, etc. ..	9	41*
Influenza	9	15
Tracheal	4	2
Bronchial	2	5
Diseases of digestive system:		
Gastric	10	19
Duodenal	0	2
Rheumatism, etc.	11	7
Injuries	5	6
Skin diseases	2	1
Hernia	2	1
Psycho-neurosis	6	8
Other causes	12	36
Total ..	74	143

Examination of the sick records and previous histories of the workers showed that none of them had ever suffered from asthma or had a spontaneous pneumothorax.

The age and sex of the group was as follows :—

	Males	*Females*		*Males*	*Females*
20–24 ..	4	1	40–44 ..	11	1
25–29 ..	15	–	45–49 ..	12	–
30–34 ..	22	–	50–54 ..	2	2
35–39 ..	19	1	Over 55 ..	2	–

* Thirty-three under four days.

Of the 92 workers 37 were at the job for more than 5 years and 31 for more than 2 years.

9 years .. 2	6 ,, .. 5	3 years .. 6
8 ,, .. 11	5 ,, .. 4	2 ,, .. 17
7 ,, .. 15	4 ,, .. 8	1 ,, .. 24

Blood Counts.—Blood counts were performed on workers in the propeller grinding shop who gave their permission for the investigation. Fifty-seven volunteered and their counts were compared with a group of 60 men from a machine shop. There was no distinct difference; the aluminium workers tended to have a polymorphonuclear leucocytosis. (See Figs. 2–5.) This is the opposite to Goralewski's findings. There is a general tendency towards a leucopenia with a relative lymphocytosis in this country at the present time, as shown by work by Britton (1943), Mottram (1943), Hamilton-Paterson and Browning (1944), and is our own finding in other factories. This may be an influence of black-out conditions, and if these are as bad in German aluminium factories as is suggested by Koelsch, they may account for the findings of Goralewski.

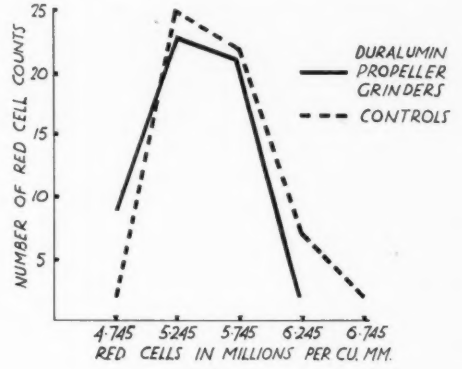


FIG. 2.

X-Ray Findings.—A mobile x-ray plant was taken to the factory and x-rays of the chest were taken of

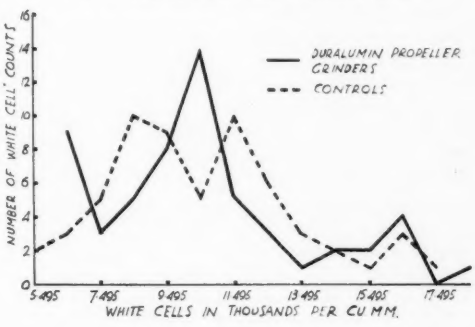


FIG 3.

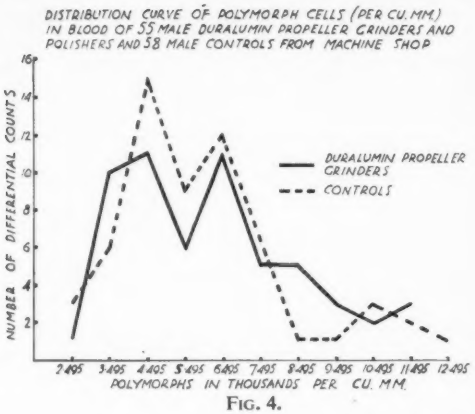

DISTRIBUTION CURVE OF POLYMORPH CELLS (PER CU. MM.) IN BLOOD OF 55 MALE DURALUMIN PROPELLER GRINDERS AND POLISHERS AND 58 MALE CONTROLS FROM MACHINE SHOP
NUMBER OF DIFFERENTIAL COUNTS
DURALUMIN PROPELLER GRINDERS
CONTROLS
2·49S 3·49S 4·49S 5·49S 6·49S 7·49S 8·49S 9·49S 10·49S 11·49S 12·49S
POLYMORPHS IN THOUSANDS PER CU. MM.

FIG. 4.

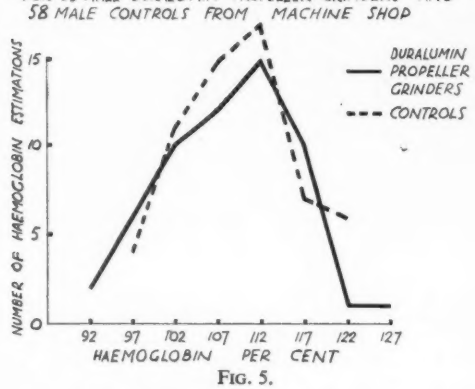

DISTRIBUTION CURVE OF HAEMOGLOBIN PER CENT (ALKALINE HAEMATIN - PHOTO ELECTRIC CELL METHOD 13·8G HAEMOGLOBIN PER 100 C.C. BLOOD = 100 PER CENT) FOR 55 MALE DURALUMIN PROPELLER GRINDERS AND 58 MALE CONTROLS FROM MACHINE SHOP
NUMBER OF HAEMOGLOBIN ESTIMATIONS
DURALUMIN PROPELLER GRINDERS
CONTROLS
92 97 102 107 112 117 122 127
HAEMOGLOBIN PER CENT

FIG. 5.

92 out of the 97 workers who were exposed to aluminium dust. The other 5 declined, but there was no reason to suppose they had any disease in their lungs. Full-sized 15 in. × 12 in. radiograms were taken and were reported on independently by Dr. M. H. Jupe and Dr. D. Jennings. There was no evidence in any of them of reticulation. In seven instances, however, there were shadows in the peripheral part of the lung which were different from the ones usually found in this situation (Fig. 6). It is conceivable that they may be due to concretions of aluminium dust. They were not related to symptoms. There were two active cases of pulmonary tuberculosis and one case which was probably arrested. These were all advised to seek treatment. There was also one example of well-marked silicotic nodulation, but this man had worked for 21 years in the South Wales coalfield.

We would like to thank Dr. M. H. Jupe and Dr. D. Jennings for their kind co-operation in interpreting the radiograms, to Mr. H. J. Ferrier of the British Red Cross Society for his help in taking the films, to Dr. N. Spoor and Dr. J. Graham for the environmental studies, and to Miss M. E. Thompson for the haematological investigation.

FIG. 6.—Contact film showing opacities seen in the periphery of the lung. The significance of these is uncertain.

Summary

The literature of the effect of aluminium and alumina is reviewed. Occupational histories, blood counts, and x-rays were taken on duralumin propeller grinders in an aircraft factory. The sick absence records were studied. There is no evidence that this dust produces any disease of the trachea, bronchi, or lungs.

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RELATIVE STERILITY OF THE HANDS OF CERTAIN METAL WORKERS *

BY

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In the course of an investigation of the flora of wounds the striking observation was made that the skin of the hands of certain workmen was remarkably free from bacteria. It appeared that the individuals in question were metal workers who handled metal filings † and engine oil. Metal workers who handled filings but not oil, those who handled oil and metal but not in the form of filings, similarly those who handled oil alone—did not present the phenomenon. Where a worker handling oily metal filings worked with his sleeves rolled up, the skin of the forearms showed the same relative lack of bacterial flora. It was found that this relative sterility of the hands was not peculiar to individuals, since control observations established that other parts of their body (neck, abdomen, thigh and arms) were just as heavily infected as corresponding parts of other people. Thus, only the parts exposed to contact with both metal filings and oil were sterile.

The phenomenon was verified on larger numbers. The investigation was carried out as follows: workmen from many different works were examined; the tests were carried out in batches and blindly, i.e. without the bacteriologist knowing the occupation of the individual whose skin was examined. Each batch of ten persons included two controls of another occupational class. For each individual a special *dossier* was drawn up containing details of previous history, hygienic conditions in general, frequency of bathing, hand-washing, and the duration of the present occupation; the fact whether the worker was in contact with metal filings (type of metal) and engine oil (whether hot) was ascertained with particular care by evidence of the worker and the manager; if any doubts arose the individual was observed at work by one of the authors. All were excluded from consideration in whom there were factors which might affect the bacteriological result, such as the use of special methods of bleaching and cleansing the skin by lotions containing detergents or hypochlorites, or the use of antiseptic soaps. Workmen in contact with tar and paints were also excluded.

The technique followed for the estimation of the bacterial flora was a modification of that originally used by De Waal in Edinburgh (personal communication). The load of infection was estimated by taking consecutively two swabs (soaked in sterile saline) from each skin area. From each individual six swabs were taken—two each from the palm, the back of the hand, and the outer side of the forearm. Samples were always taken from similar areas of an inch square of the right extremity; the interval between the last hand-wash and the taking of the swabs was at least two hours. Each swab was plated on two blood-agar Petri dishes. (No search for anaerobes was made.) The approximate number of colonies obtained by averaging the growth on the four Petri dishes was expressed in grades according to the following scale:

Grade	Number of colonies per Petri dish
0	0
1	1–10
2	11–25
3	26–50
4	51–100
5	101–250
6	251–500
7	501–1000
8	1001–2500
9	2501–5000
10	5001+

Almost 50 per cent. of all individuals were examined twice at a fortnight's interval—the difference between the two was negligible; the results quoted for such individuals are the average of the two examinations.

A series of 40 oily metal-filings workers was compared with a control population of 86 individuals comprising various occupations—22 carpenters, 18 clerks, 17 medical personnel (10 doctors, 7 nurses), 12 metal workers not in contact with both metal filings and oil, 9 porters and labourers and 8 housewives.* Differences of social class were purposely *not* avoided, since it was thought that better financial conditions might favour personal hygiene and bacteriological cleanness; thus a con-

* Work done with the support of the Scottish War Wounds Committee of the Medical Research Council.

† The metal filings were derived from shells, ships' plates, brass and steel plates and various alloys containing copper, manganese, etc., which cannot be specified more particularly.

* Many more workers of both groups have been examined; though the results obtained with them were similar to those given below, they were excluded from statistical analysis because detailed information regarding their personal hygiene could not be ascertained.

trol population consisting of many social classes including medical personnel, puts the odds against the population of oily metal-filings workers, and so makes the finding of relative sterility of the latter more significant, particularly as with few exceptions the oily metal-filings workers had only one bath a week and one hand-wash a day after their work. The group of oily metal-filings workers contained only males, and of the control about one-eighth (11) were females; thus difference of sex was practically excluded.

The palm of the hand rather than the back was chosen as a criterion for analysis for the following reasons—it was found that the back of the hand is subject to greater individual variations in the load of bacteria than the palm; in several instances among the control population the back of the hand was found relatively 'clean,' but only once was an 'almost sterile' palm encountered; this was in the case of a surgeon shortly after washing the hands. (A few hours later the hand was found again to be heavily infected.) It was also thought that the back of the hand was less in contact both with sources of infection and possible antiseptic agencies (metal filings and oil).

Results

Table 1 shows the frequency distribution of individuals in (a) the population of oily metal-filings workers and (b) the control population according to grades of bacterial infection of the skin of the palm.

It appears from the table that (a) the population of oily metal-filings workers is strikingly bacterium-free; 30 per cent. of it falls into grade 0; 87·5 per cent. into grades 0–2, and 92·5 per cent. into grades 0–3. (b) The control population is much more heavily infected; none of it falls into grade 0, the bulk of it—59·2 per cent.—into grades 4–6, the rest is spread over all other grades. Comparison of the carpenters with the rest of the control population, using a fourfold table, yields a value of P between 0·02 and 0·01, so that there is probably a significant difference. However, the carpenters were not excluded from the controls, in order that the test of significance of the difference between oily metal-filings workers and others might be as stringent as possible. The group of 17 individuals belonging to the medical personnel is entirely similar to the rest of the control population. Thus the oily metal-filings workers are in a class by themselves.

The difference of bacterial load of the population of oily metal-filings workers and the control population has been tested by calculating the χ^2 of such distribution (Table 2) and by calculating the relation

TABLE 2

FOURFOLD TABLE SHOWING INCIDENCE OF CLEAN AND DIRTY INDIVIDUALS IN THE TWO CATEGORIES OF OILY METAL-FILINGS WORKERS AND CONTROL OCCUPATIONS (TAKING GRADE 2 AS LIMIT OF CLEANNESS)

	Oily metal-filings workers	Various other occupations	Total
Clean Grade 0, 1 and 2 ..	35	12	47
Dirty Grade 3 and above	5	74	79
Total	40	86	126

$\chi^2 = 60{\cdot}03$ $\quad P = ca.\ 10^{-12{\cdot}231}$

The χ^2 was calculated according to Bradford Hill (1942). The value of P was taken from the tables of Pearson (1924).

TABLE 1

Grade	Oily metal-filings workers		Control population				
			Carpenters	Medicals	Others	Total control population	
	Number	Per cent.	Number	Number	Number	Number	Per cent.
0	12	30·0	0	0	0	0	0
1	16	40·0	4	1	0	5	5·8
2	7	17·5	4	1	2	7	8·1
3	2	5·0	3	1	2	6	7·0
4	2	5·0	4	7	11	22	25·6
5	1	2·5	0	3	13	16	18·6
6	0	0	2	2	9	13	15·0
7	0	0	3	1	2	6	7·0
8	0	0	1	0	4	5	5·8
9	0	0	1	0	1	2	2·4
10	0	0	0	1	3	4	4·7
Total ..	40	—	22	17	47	86	—

The organisms isolated were in decreasing order of frequency, *Staph. albus*, haemolytic diphtheroids, various *sarcinae*, non-haemolytic diphtheroids, anthracoids, yeasts, mucors, penicillia, aspergilli, *Staph. aureus*, *Enterococcus*, *Pneumococcus*, *Str. haemolyticus*, *Str. viridans*, non-haemolytic streptococci, Gram-positive air cocci and bacilli, coliforms, micrococci and Klebsiellas.

of the difference of proportions of clean individuals in both populations, to the standard error of their difference, i.e. the significance of the difference (Table 3). For both calculations grade 2 has been taken as the limit of bacteriological cleanness.

TABLE 3

TABLE SHOWING THE PROPORTION OF CLEAN INDIVIDUALS IN THE TWO CATEGORIES OF OILY METAL-FILINGS WORKERS AND CONTROL OCCUPATIONS, TAKING GRADE 2 AS LIMIT OF CLEANNESS

Proportion of clean individuals in—	
(a) Oily metal-filings workers ..	87·5 per cent.
(b) Control population	13·9 ,,
Percentage difference between the two populations	73·6
The standard error of this difference ..	6·42 per cent.
The difference is 11·46 times its standard error.	

Discussion

It appears from the present study that the skin of the palm of workers in contact with metal filings and oil carries a lower load of bacteria than that of other people, and statistical assessment indicates that the phenomenon is not likely to arise by chance. It may therefore be concluded that there is an association between contact with metal filings and the bacteriological cleanness of the skin, which is presumably causal.

The explanation of the relative sterility of skin exposed to metal filings and oil is not clear. One of the factors might be the diminished chances of bacterial contamination of oily metal filings workers. The findings, however, with medical personnel and metal workers not in contact with metal filings and oil, do not favour such an explanation; the hands of oily metal-filings workers are strikingly clean in the bacteriological sense irrespective of the hygienic conditions. Experiments *in vitro* suggest that the phenomenon is related to the oligodynamic action of fine metal particles—i.e. the antiseptic action produced by traces of such substances, owing to their being electively fixed by sensitive organisms and so accumulating in these. The relative sterility of the hands of carpenters is probably related to the antibacterial action of moulds, anthracoids, etc., acquired through handling wood and sawdust. Such organisms are present in those materials as well as on the hands and *in vitro* almost all the species were capable of inhibiting the common organisms of the human skin, such as *Staph. albus* and *aureus*, sarcinae, diphtheroids and enterococci.

In view of the influence which the bacterial flora of the skin exerts on the infection of wounds and so on the rate of healing, the relative sterility of those who handle oily metal filings is not merely of theoretical interest. The somewhat surprising information was elicited from those men that injuries to their hands usually healed without becoming septic; this was borne out by our experience. Since 'greasy' occupations frequently involve contact with metal in fine division the statement of Iselin (1940) that 'the hands of workmen and particularly those soiled with grease, appear to harbour only attenuated organisms' may refer to this class of cases.

We are indebted to Mr. W. Arthur, Department of Mathematics, the University, for scrutinizing the statistical analysis.

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PHYSICAL NATURE OF RADIATIONS USED IN INDUSTRY *

BY

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The principal radiations may be divided into two types, corpuscular and electro-magnetic radiations. Corpuscular radiations are those having the properties of particles, as, for example, alpha rays, beta rays and neutrons, while electro-magnetic radiations are those with wave-like properties. Examples of electro-magnetic radiations are gamma rays, x-rays, ultra-violet and actinic rays, visible radiation, infra-red rays and radio waves. Though this division is justified by experiment it should be pointed out that recent experiments have demonstrated that particles show wave-like properties and waves particle-like properties.

Corpuscular Radiations

These radiations are emitted in the natural or artificial disintegration of atomic nuclei.

Alpha particles are the nuclei of the gas helium; they carry positive charges and have four times the mass of the hydrogen atom. They are copiously and continuously emitted by naturally radio-active substances like radium and occur with well-defined energies, usually about 5 million electron volts. On the average they travel with one-twentieth of the speed of light. In spite of their high energies and great speeds alpha particles have little penetration because they dissipate energy rapidly by the formation of ions. An alpha particle with a range of 4 cm. in air at atmospheric pressure (equivalent to a thin sheet of paper), produces as many as 275,000 ions along its track. The tracks left by alpha particles can be made visible by the Wilson cloud chamber. A photograph of alpha particles tracks is reproduced in fig. 1. The intense ionization and the straightness of the tracks may be noted.

FIG. 1.—Tracks left by alpha particles in the Wilson cloud chamber. (After Blackett and Lees.)

Beta particles are high speed electrons ejected from radio-active nuclei or from the outer shells of electrons by gamma rays. Their energies range up to 10 million electron volts and they have velocities approaching the velocity of light. The ranges of beta particles are much greater than alpha particles because the ionization loss along their paths is much less. The small ionization loss is shown by the thinness of the track left in the Wilson cloud chamber. A high-speed beta particle has a range of about 1000 cm. in air or 1 cm. in water. Beta particles are highly scattered. If a beam of beta particles falls normally on a thin sheet of metal of high atomic number, 50 per cent. of the beam is scattered through more than 90 degrees.

Neutrons are not yet used in industry. They are neutral particles of mass equal to the hydrogen atom and are emitted in large numbers when certain elements, e.g. beryllium, are bombarded with the alpha particles from radium. They may be produced artificially by the Lawrence cyclotron. Their ranges are very great because their ionization loss in matter is extremely small. They are very difficult to absorb. The best absorbers known are water and paraffin.

Electro-magnetic Radiations

Electro-magnetic radiations have wave-like properties, that is they show the phenomena of reflection, refraction, dispersion, interference and diffraction. The only difference between the different types of radiation is a progressive change in wavelength from the shortest electro-magnetic radiation known, gamma radiation, to the longest, radio waves. They all travel with the velocity of light.

* A post-graduate lecture given at Manchester University, January 30, 1944.

Many of the properties of these waves can be illustrated by water waves. Thus if two sets of water waves of the same wavelength cross, interference effects are observed in the region of crossing. At some places in this region much higher waves are observed while at other places there is still water because the 'humps' of one set of waves overlap the 'hollows' of the other set. Exactly the same effect is observed in the case of light and x-rays (see fig. 2) and, in fact, for all electro-magnetic radiations. The dark lines in the figure correspond to regions of destructive interference, i.e. no light, and the bright lines to regions of constructive interference. By this and many other experiments it has been proved that all the radiations classified as electro-magnetic have similar properties.

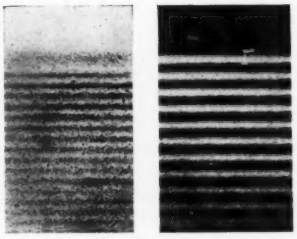

FIG. 2.—Interference fringes taken with (*a*) x-rays of wavelength 8·33 A.U. (after Kellstrom), and (*b*) visible light of wavelength 4358 A.U. (after White).

Gamma rays are electro-magnetic radiations of wavelengths from 0·005 to 1·3 A.U. emitted by radio-active nuclei. Their penetration is very great, the intensity being reduced only 50 per cent. by 2 inches of iron. Energy is lost by the production of beta particles (photo-electrons ejected from the outer shells of atoms), scattering and, for very short waves, the creation of pairs of electrons.

X-rays are electro-magnetic radiations of wavelengths from 0·01 to 10 A.U. A thickness of 3·5 cm. lead is needed to protect the body from 600 Kv. x-rays. Wilson cloud chamber photographs show that x-rays lose energy by the production of photo-electrons (see fig. 3), and by scattering. The medical effects are due to photo-electrons. The total length of track of all the photo-electrons produced in a small volume of the body by a comparatively short irradiation with x-rays may be of the order of thousands of miles.

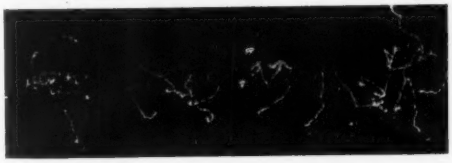

FIG. 3.—Tracks left by electrons in the Wilson cloud chamber; tracks are from low energy photo-electrons (produced by a beam of x-rays) which are identical with slow beta particles. (After Nuttall.)

Ultra-violet and actinic rays (wavelength range, 2500–4500 A.U.), *visible radiation* (4000–8000 A.U.), and *infra-red rays*, correspond to energies of from 5 volts and 0·1 volts. Medical effects may be physiological, photo-chemical or thermal. These radiations may be emitted or absorbed by matter in the form of line, band or continuous spectra. Line spectra are associated with electronic energy changes in atoms while band spectra are associated with electronic, vibrational and rotational energy changes in molecules. Continuous spectra may be produced by atoms or molecules in the gaseous, liquid or solid states. The continuous spectra produced by liquids and solids may be due to line or band absorption broadened to continua by the intense atomic and molecular fields. Examples of line and band emission spectra are shown in fig. 4. An example of line absorption spectrum is the Fraunhofer spectrum of the sun which is due to the absorption by the cool gases in the outer layers of the sun of the continuous spectrum emitted by the white-hot interior. A good example of very important continuous absorption is the narrow absorption band of chlorophyll in the near infra-red. By this absorption band vegetation absorbs energy from the sun and life on the earth is made possible.

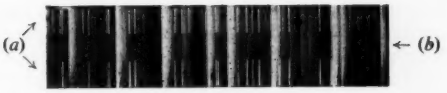

FIG. 4.—Examples of line and band emission spectra. The line spectrum, marked (*a*), is part of the spectrum emitted by the iron arc; and the band spectrum, marked (*b*), is emitted by the diatomic molecule antimony fluoride (SbF). The line spectrum is superimposed on the band spectrum.

Summary

A description is given of the physical nature of the principal radiations used in medicine. The radiations are divided into two main types, corpuscular and electro-magnetic radiations. The corpuscular radiations include alpha particles, beta particles and neutrons; while the electro-magnetic radiations include gamma rays, x-rays, ultra-violet radiation, visible radiation and infra-red rays. The medical effects are for the most part due to the production of photo-electrons but they may also be physiological, photo-chemical or thermal.

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MEDICAL ASPECTS OF RADIATIONS USED IN INDUSTRY *

BY

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Present knowledge of the potential danger of many varieties of radiation, and of the measures necessary to safeguard industrial workers against such danger, is based first upon the actual experience of early research workers in this field, and, second, upon preventive measures instituted by various medical bodies for personnel engaged in x-ray and radium therapy.

The radiations with which industry is chiefly concerned are x-rays, infra-red, light, and ultra-violet rays, radium, and to a much smaller extent, ultra-short waves.

X-rays

The story of the injuries received by pioneers in the x-ray field is a sad one, so well known that only brief reference need be made to it. It is interesting to note, however, that Röntgen himself, who discovered x-rays in 1895, escaped injury chiefly because most of his experiments were photographic only, and also because he used x-ray tubes placed in a zinc box and protected by lead screens.

Reports of soreness of the eyes, dermatitis and loss of hair began to come in about 1896, but even in 1899 it was still believed by many authorities that these were due to chemical or electrical conditions in the skin or, as in the case of Dr. Hall Edwards who eventually died of x-ray cancer, to the developer used. The first case of x-ray cancer in a workman employed in making x-ray tubes, and developing from a lesion on the back of the hand, was described in 1902 ; but Dr. Hall Edwards' reports on his own injuries in 1904 provide the classical description of this fatal condition. The redness of the skin, transverse lines on the brittle nails, cracks of the epithelium, warty growths, sores which would not heal, and the very severe pain, finally necessitating amputation of fingers and forearm, form a picture which was to be repeated in other unfortunate victims before the necessity for suitable preventive measures was fully recognized.

Injuries due to X-rays. Injuries to the *skin* are perhaps the best known signs of x-ray damage, perhaps because they are so obvious, especially in the acute stage. An x-ray burn may consist only of a patch of acute erythema, which gradually disappears in the course of a few weeks, but it may go on to necrosis and ulceration which is extremely difficult to heal. It is probable, however, that a single burn never initiates cancer. Chronic x-ray dermatitis is a different and entirely characteristic pathological condition, involving processes of both atrophy and regeneration. Side by side with atrophic loss of the epidermal appendages and obliteration of small blood vessels, leading to areas of necrosis beneath the epidermis, goes reparative proliferation of surrounding tissues. The clinical signs of this combination of atrophy and repair are thickening of the epidermis, hyperkeratosis, cracks, with degenerative changes in the deeper tissues—in other words, a pre-cancerous condition.

There are also the later skin reactions, appearing only some time after exposure has ceased, even as long as several years after. These may consist of telangiectases, areas of pigmentation and atrophy, localized thickenings and warts, generally on the dorsum of the hand, or later ulceration due to obliterative endarteritis and lymphangitis.

The *blood changes* caused by excessive exposure to x-rays are shown first of all by the white cells. A gradually increasing leucopenia, sometimes preceded by a transient leucocytosis, is the most constant diagnostic sign. The leucopenia is often accompanied by a lymphopenia, since the lymphocytes are specially sensitive to x-rays, or sometimes by a relative lymphocytosis. If this condition is detected at an early stage and the subject removed from exposure, it is entirely curable, but if allowed to progress it may culminate in severe and even fatal depression of the bone marrow—aplastic anaemia. Cases of leukaemia as the final stage have also been reported, but there appears to be some doubt as to the direct connection between the condition and general x-ray radiation. There seems no scientific reason, however, why leukaemia should not be the end-result of an aplastic marrow, possibly as an over-compensatory regenerative process. We do know that benzol poisoning, which characteristically causes aplasia of the bone marrow, does at times end fatally, with the bone marrow in a condition of hyperplastic leukaemia; and, in fact, benzol leukaemia, though not nearly so common as benzol anaemia, is a recognized clinical entity.

* A post-graduate lecture given at Manchester University, January 30, 1944.

With regard to the *generative organs*, sterility has been known to occur in some male radiographers when protection has been inadequate. Some of these cases have eventually recovered. In female radiographers and nurses the percentage of sterility has been found to be high, and there is said to have been a rather high percentage of developmental defects in any children born, but the evidence is not conclusive.

Industrial Uses. The use of x-rays for detecting flaws in castings and other metal articles and in diffraction processes is constantly increasing and the voltage of the apparatus varies considerably. For small castings of light alloys the range is usually from 30 to 100 kilovolts; for heavy large castings, such as bomb-carriages, from 100 to 200 kv. and in some cases up to 400 kv. In America much more powerful installations—up to 1000 kv.—are used, but have not yet been introduced into this country.

The chief danger to x-ray operatives arises when the work is chiefly screening, rather than photography. Protection from the direct beam can, of course, be afforded by lead screening of the tube. The danger of *scatter radiation* is less obvious and therefore often less carefully guarded against, and it has not been unusual, until fairly recently, to find x-ray rooms littered with numerous articles awaiting examination, all acting as contributory sources of scatter radiation.

Preventive Measures. The measures at present recommended to all users of industrial x-rays are based on the original recommendations of the British X-ray and Radium Protection Committee, which was formed in 1921 with the object of preventing casualties to x-ray and radium workers. These formed the basis of the International Recommendations adopted at Stockholm in 1928 by the Second International Congress of Radiology. They included general hygienic conditions for x-ray rooms —size, ventilation, temperature and layout of the apparatus; protection of the x-ray tube by a sufficient thickness of lead or its equivalent; the use of mirrors; provision of screens for fluorescent work; protection against scatter radiation by placing the operator outside the x-ray room behind walls containing the necessary lead or its equivalent; protective clothing; a working week of not more than 35 hours with four weeks' holiday a year; and periodical blood examinations. These recommendations are designed to limit the exposure received by the operator to what is considered the tolerance dose of one R per week, and to detect the earliest signs of injury.

Application to Industrial X-ray Exposure.—These preventive measures apply with equal force to the protection of industrial x-ray operatives, though they are not at present statutory. Naturally, a continuous check is kept by the Factory Department on the conditions obtaining in the x-ray industrial field. It has to be remembered that, even with a well installed and well protected x-ray apparatus, the human factor comes into play more markedly with the industrial worker, who is less likely to be aware of the danger and more likely to take liberties with it, than with the trained medical radiographer. X-ray burns, for instance, should not occur with a fully protected installation and lead rubber gloves, but even where these conditions have been fulfilled and where advice and instructions have been given, they have occurred, because the worker has been unable to realize that putting his uncovered hands in the track of an invisible ray even for a short time could do any harm.

It will be appreciated that the work in factories differs from that in hospitals; longer hours and more continuous spells may have to be worked, and the risk of scatter radiation may be greater. The Chief Inspector of Factories decided therefore, in 1942, after consultation with representatives of various interested bodies, to have a preliminary survey made of the actual conditions of exposure in factories using x-rays. A circular letter was sent to managements inviting them to co-operate in a scheme by which the National Physical Laboratory undertook to measure the dosage revealed by dental films worn for one week by the operatives. If these showed evidence of a dosage greater than the tolerance dose of one R per week, the National Physical Laboratory would investigate the plant, and the operative in question would be asked to undergo a blood examination. In this way it is hoped to link up actual exposure with the condition of health of the workers. The results so far have been very encouraging with regard to the dosage which industrial x-ray workers on the whole are receiving. In nearly all the large number already investigated the dosage varied from 0·1 to 0·3 R per week—well below the tolerance dose.

Infra-red Rays and Light

Certain industrial occupations, such as welding or brass foundry work, involve exposure to all three varieties of radiation—infra-red, light, and ultra-violet; in glass manufacture it has been shown that infra-red is the chief harmful component; and in electro-welding the light and ultra-violet rays form the greater hazard. Exposure to excessive light, as in gazing at bright objects, may cause transient scotomata which disappear on rest and can be prevented by wearing suitable glasses such as those prescribed by the British Standard Specification Pamphlet No. 679. Infra-red radiations physiologically produce vasodilatation of the skin vessels, and stimulation of cell activity, thus promoting healing and tissue repair. They do not penetrate very far before being converted into heat, but some do penetrate the dermis and may cause an actual rise of body temperature. In excessive dosage they produce severe metabolic disturbance, skin burns and lesions of the eye.

Industrial Exposure and Injury. The chief processes in which excessive exposure to infra-red radiation is likely to occur are foundry work, welding, glass manufacture, and some varieties of furnace work. Heat cramps are, of course, a

severe metabolic effect which includes the inevitable dehydration of the tissues and loss of salt. The provision of saline drinks is a well-recognized preventive measure for the heat colic from which those who work in excessive heat frequently complain.

On the *skin*, infra-red rays produce an erythema which may amount to severe burning, followed by pigmentation which is sometimes permanent and may also be accompanied by chronic inflammatory changes.

Changes in the *blood* are not so well recognized as a consequence of infra-red radiation but some authorities believe that severe and continuous exposure may cause anaemia and leucopenia.

Cataract.—The industrial injury which is the chief recognized effect of infra-red radiation, and which is subject to compensation, is cataract following exposure to molten glass or red-hot metal. Historically, glass-workers' cataract is of great interest. It has been observed in Germany since 1896, and in 1903 Dr. Robinson, surgeon to the Sunderland and Durham County Eye Infirmary, published a paper drawing attention to the frequency of cataract in bottle finishers in the glassworks of that district. This was followed up by Sir Thomas Legge, who compared the incidence of cataract in glass workers with that of a large number of operatives who were not glass workers and who showed that changes in the lens were in fact about five times as frequent in glass workers between 30 and 40 years of age, twice as frequent between 41 and 50, and three times as frequent over 50.

The character of the cataract differs from that of the ordinary senile variety in that it always commences at the posterior pole of the lens and involves the cortex, whereas in senile cataract the characteristic change usually develops in the form of radiating lines from the periphery, the central pupillary area remaining free. The explanation given by Robinson of the difference was that the posterior pole was practically the optical centre where the principal rays from the furnace crowd together, cross, and pass on without refraction. That it was the infra-red rather than the ultra-violet rays which were responsible for the cataract was shown by Sir William Crookes during his researches on suitable protective glasses; he found heat rays in far greater abundance than ultra-violet in the radiations from molten glass.

Ultra-Violet Rays

Modern knowledge of the effects of ultra-violet rays is really due to Finsen. It is rather curious that Finsen should at first have devoted his studies entirely to the harmful effects of ultra-violet radiation and only later, in 1897, turned his attention to their beneficial action in the treatment of lupus vulgaris.

The physiological effects of ultra-violet rays are exerted chiefly on the skin, the superficial blood vessels and the haematopoietic system in general. The erythema produced only appears after a latent period of from 4 to 12 hours and lasts for a time depending on the severity of the exposure. The degree of pigmentation produced, now known to be a protective reaction, is not directly related to the intensity of the erythema. The effects on the *blood* are seen in an increase in the number of red cells, and a slight increase in the total white corpuscles for which the lymphocytes rather than the polymorphs are responsible. There is also an increase in blood platelets and serum calcium.

Industrial Uses and Injuries. There are many modern industrial processes in which ultra-violet rays are used, as it were, deliberately, for their revealing power, just as x-rays are. The examination of golf balls to detect defects in the painting and undercoating, the examination of blue-prints and razor blades, of linen marked with invisible ink, and of luminized dials, are some examples of this type of use. In these processes there is very little risk of injury to the eyes since both lamps and personnel are usually well protected and, also, since many of this kind of apparatus emit not true ultra-violet but 'near' ultra-violet with a wavelength of 3000 to 4000 A.U. The destructive effects of ultra-violet radiations on the eye tissues is greater the shorter the wavelength; that is to say, it rises sharply between 2000 and 2400, is more gradual from 2400 to 2900, and is almost negligible when the wavelength is greater than 3000 A.U. The chief trouble arises when ultra-violet rays are emitted during processes for which they are not specifically desired, such as electro-welding. The eye injuries caused by excessive ultra-violet radiation show themselves, like the skin erythema, after a latent period of some hours. They begin with symptoms of severe conjunctivitis, smarting, lachrymation, photophobia and sometimes chemosis. In severe cases the cornea may become inflamed and corneal ulceration and iritis may follow. Many authorities believe also that the lens may be injured and that cataract may be a final result, as it is of infra-red radiation.

Prevention. The most logical and successful prevention of injury to the eyes by infra-red, actinic or ultra-violet rays, is the provision of either spectacles or screens of glass which intercept the wavelength in question. For processes involving exposure to these wavelengths eye protective glasses are available, designed according to the British Standard Specification. These glasses are graded according to the proportion of the different radiations absorbed by them and are suitable for different types of work—for example, Grade A for lead-burning, lead-brazing and melting furnaces up to about 1600° C., Grade B for acetylene welding, Grades C and D for metal-arc lamps, and Grade E for carbon-arc lamps used in carbon-arc welding and cutting. For protection against ultra-violet radiation alone, for example from a distant arc, Crookes' special glass is suitable. It absorbs very little visible light but all the dangerous ultra-violet. A detailed description of all the various glasses will be found in the B.S.S. pamphlet on 'Protective Glass for Welding, 1936, No. 679.'

Radium

The credit for the actual discovery of radium goes, of course, to the Curies, who isolated it in 1898, though Becquerel had previously shown that uranium gave off active radiation.

Injuries due to Radium. The first evidence that this potent substance might cause injury to living tissue was shown, as in the case of x-rays, by skin lesions. Pierre Curie suffered from radium dermatitis, but the best-known example of its acute effect was the burn received by Becquerel in 1901. He carried a tube containing some decigrammes of impure radium chloride in his waistcoat pocket for six hours, and was surprised later to find a patch of acute erythema on his abdominal wall, followed by ulceration which took over a month to heal.

Much more serious consequences followed exposure to radium in America from 1917 to 1924. The luminizers of New Jersey are the classical example of true radium poisoning, caused by the accumulation in the tissues of radium which had almost certainly been ingested, owing to the habit of the luminizers of pointing with their lips the brushes which they used for applying the luminous paint. The necrosis and in some cases sarcoma of the jaw which preceded death in 15 cases was no doubt partly due to local infiltration by this mode of entry, but probably also to the fact that the trabecular structure of the jawbone makes for low resistance to infection. Combined with these lesions of the jaw was severe aplastic anaemia. In ten other fatal cases there were malignant tumours of other bones. Dr. Robley Evans of Massachusetts Institute of Technology has also called attention to cases of rarefying osteitis with spontaneous fracture. It is noteworthy that only those luminizers who had been employed one to two years or longer were affected, and in many the disease did not show itself until as long as 5 or 6 years after they had ceased work.

These cases are the outstanding examples of radium poisoning due to the cumulative effect of radium deposited in the body, but other similar cases have occurred following the ingestion of radio-active medicaments such as radio-active waters containing as much as 2 microgrammes of radium in a two-ounce bottle. One case described by a pathologist who was present at the post-mortem examination was that of a man who had died of aplastic anaemia of apparently unknown origin. It was discovered, however, that he had drunk radio-active water for rheumatism for the past 12 years, and examination of the tissues showed the presence of a considerable amount of radium. It should be mentioned here that the natural radio-active water of some British spas contains only the most minute traces of radium and, of course, the human body normally contains traces of radio-active material.

In considering the injuries which may be caused by radium it is necessary to remember that all three types of radiation which it emits, as well as the radon gas which is constantly emanating from it, have separate potentialities for harm. *Alpha particles*, which are the most destructive, are fortunately also the least penetrating and their entrance into the tissues from outside can be most easily guarded against. But in cases where radium has been deposited in the body, especially in the bones, either by ingestion or long-continued inhalation of radium dust, alpha particles can keep up a continuous bombardment of the bone marrow and other tissues, with serious results.

Beta particles are less destructive to tissue but have more penetrating power than alpha particles; they need several millimetres of metal or glass for complete screening. Their chief action is on the skin, causing radium dermatitis.

Gamma rays are a true radiation of great penetrating power; only half of their intensity is lost after passing through about 1·5 cm. of lead. Their chief action is upon the blood-forming organs, causing depression of the bone marrow, which if allowed to continue might lead to fatal aplastic anaemia.

Radon is a colourless gas, without taste or smell, which is being continuously formed from radium and which is itself continuously being transformed into the next radio-active element, radium A. It is obvious that prolonged and continuous inhalation of radon must in time add to the risks of damage from external radiation or ingestion of radium dust.

In considering the risks to health of radium workers, therefore, four possibilities must be borne in mind. (1) *True radium poisoning.*—This was seen in its worst form in the New Jersey cases. (2) *Respiratory lesions.*—These have been observed chiefly among the uranium workers in Joachimsthal in Bohemia, where the incidence of lung cancer is high. This disease, known locally as 'Bergkrankheit,' was at one time thought to be due to inhalation of either arsenic or other metallic particles, but more recent authorities have considered it due to inhalation of radon given off by the radium chloride in the uranium ore. (3) *Injury of the blood-forming organs.*—A gradual depression of the white cell count, leading in time to aplastic anaemia. (4) *Skin injury.*—Like x-rays, radium may produce an acute burn or patch of erythema, or a chronic dermatitis of atrophic character. It is believed, however, that chronic radium dermatitis is less likely to develop into skin cancer than the dermatitis caused by x-rays.

Industrial Uses. The chief use of radium in this country is the application of 'luminous compound' to aeroplane and watch dials, compasses, gun sights and various electrical instruments.

Luminous compound in its dry form is a powder consisting of zinc sulphide with a small admixture of radium or mesothorium, the usual proportion being 70 micrograms of radio-active substance per 1 gramme of compound. By far the greater part of the luminous compound in this country is used in the form of a paint, made by the addition to the powder of various mucilages and solvents; a small

amount is used dry. The reason for the addition of radio-active material to zinc sulphide, which is in itself phosphorescent, is to prolong the period of luminescence when any source of light is removed.

Prevention of Injury to the Health of Luminizers. The preventive measures for the luminizing industry are embodied in the Factories (Luminizing) Health and Safety Provisions Order of 1942, and the Amendment to the Order 1943. In addition to the statutory obligations imposed on both employer and employee by this Order, two further precautionary measures have been in use for some time. These are the six-monthly blood examinations of every luminizer, and estimations of the radon content of their exhaled air and of the air of the luminizing room. So far it would appear that strict enforcement of the provisions of the Luminizing Order and continual instruction to the luminizers themselves has prevented consequences of anything like the severity of the New Jersey occurrence. There have been no cases of fatal radium poisoning, none even of true aplastic anaemia, and the skin effects which have been observed have been slight and in most cases transient.

In order to prevent the occurrence of chronic dermatitis from direct contact with luminous compound or with radiation from open containers, a protective covering, consisting of a section of brass tubing with the oblique top filled in with a perspex lid through a small hole in which the applicator was inserted, was designed by Professor Mayneord of the Royal Cancer Hospital (see fig. 1). Most managers have accepted this appliance with great willingness.

Blood Examinations.—In no case has evidence of true aplastic anaemia been found. Slight leucopenia has occurred in comparatively few cases, nearly always in supervisors who usually weigh out and mix the luminous compound and who are therefore exposed to heavier dosage than the girls using small quantities of paint at a time. In all cases where leucopenia has occurred at successive blood examinations this has been brought to the notice of the Examining Surgeon who has then suspended the luminizer for three months; at the end of that time she is re-examined and only reinstated if her total white count has returned to normal. The red cells and haemoglobin have shown very little variation, except that during the first few months of employment the values are rather higher than one would expect in girls of this age and probable nutritional level. It is not at all unusual to find counts of 5 million r.b.cs. and over, and haemoglobin percentages of 100–102 per cent.

The most interesting and striking feature of the blood picture of a large proportion of these girls, especially during the first six months, is a high degree of relative lymphocytosis with a total white cell count of 6000–8000, or even higher. In these latter cases this amounts, of course, to an absolute lymphocytosis. In addition, the stained smears frequently contain immature cells such as premyelocytes, Türk cells, and even occasionally myelo-

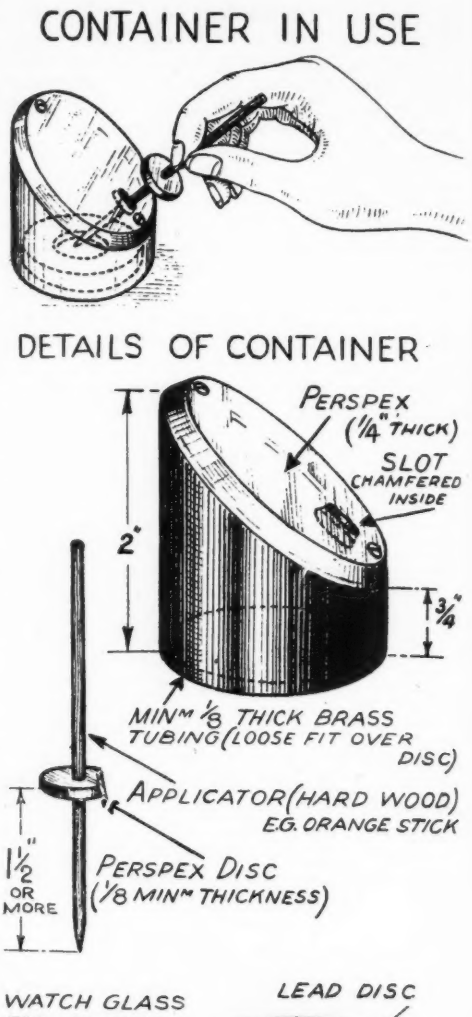

FIG. 1.—Mayneord's protective container.

blasts. Usually these abnormalities subside in the course of a year or eighteen months and the count remains normal for as long as they remain in employment. It has not been possible to follow their further development, because many of these girls have changed their work, or married, but in a very few cases who have shown this tendency at the beginning, and then become normal, and who have stayed on for a number of years, a trend towards a gradual lowering of the total white count has been observed. The statutory obligation under the

Amendment Order that all luminizers employed more than a year shall have three months of complete removal from exposure will no doubt prevent this trend towards a depressive effect from degenerating into a true leucopenia. Consultation with many haematologists as to the significance, if any, of the initial lymphocytosis and the presence of abnormal cells, appears to confirm the author's opinion, which is that it represents an initial stimulative effect of small doses of radio-active material. In itself the phenomenon is not necessarily harmful, but it must be remembered that hyper-stimulation over a long period might eventually produce depression.

Radon Estimations.—An attempt is being made here, as has already been done by Robley Evans in America to keep a further check on the health of luminizers by estimation of radon in their exhaled air, in order to ascertain whether in fact any radium is deposited in the tissues. Research is being carried out on these lines, under the direction of the M.R.C. by Professor Russ of the Middlesex Hospital, and it is hoped to make further use of the results, but there are great difficulties of technique and of arriving at definite conclusions. The method will, it is hoped, be a valuable adjunct to the prevention of serious effects.

A *dental film test*, similar to that for x-ray workers, is also being worked out by the National Physical Laboratory.

It will be seen, therefore, that while at present there is no reason to fear for the health of luminizers, it is very necessary in view of the cumulative effect of radium, and again taking into account the human factor which sometimes defeats the strictest regulations, not to relax a single precaution and to keep a constant watch on any developments that might arise. So far as the Factory Department is concerned, this is being done.

Short Waves

A brief reference must be made to 'short waves.' As in the case of x-rays and radium, most of our knowledge of the biological effects of this variety of radiation comes from the clinical field, where short-wave therapy has been in use for some time in the treatment of inflammatory conditions, rhinitis, asthma, sepsis and the results of trauma. In industry, short waves are not at present widely used. Before the war there was a gradually increasing manufacture of television receivers and of medical short-wave apparatus, and both these sources of short-wave radiation will no doubt increase during the post-war years. It is necessary, therefore, to have some idea what danger, if any, is to be apprehended if their use becomes more extensive.

So far the only symptoms complained of have been discomfort from sensations of heat, headache and drowsiness. It appears more than probable that these are entirely a heating effect, since in actual short-wave therapy, as in diathermy, heating of the tissues is a known and desired effect.

It has often been stated that the favourable effect of short-wave therapy is due chiefly to dilatation of capillaries, but recent observations, by means of special microscopic technique, of human capillaries while short-wave therapy was being carried out, showed that there was no marked alteration in the calibre of the capillaries; there was, however, a marked increase in the rate of blood flow, which probably accounted for the rapid subsidence of oedema and resolution of septic processes. It has been suggested that the chief danger to persons exposed to short waves might arise from their selective absorption by the body owing to the great variation in resistance of the various organs and tissues, and that over-heating of the blood might be associated first with the possibility of thrombosis, and second with damage to projecting parts of the body because of the reversal of the normal cooling process—that is to say, these parts would receive heat from the blood instead of having it taken away.

In actual practice, so far as all inquiries have shown, no such dangers have arisen, and the discomfort from overheating can be minimized by suitable precautions. These include: (1) Keeping out of the field as much as possible. Distant control of the apparatus is the obvious solution. (2) Using the apparatus in atmospheric conditions which best provide regulation of the body heat. This could, of course, be achieved by artificial movement of the air. (3) Suitable screening. At the same time it must be emphasized that beyond the physiological effects described little is known of any other biological or possibly cumulative properties of these rays, and if their use ever becomes an industrial problem of any magnitude a promising field of research and of vigilance will be open to the industrial medical officer.

Summary

X-rays. Used for detecting flaws in metal. Screening more dangerous than photography; 'scatter' radiation requires special precautions. Injuries—skin lesions (burns, dermatitis, pigmentation, warts, malignancy); blood changes (leucopenia, aplastic anaemia, even final leukaemia); sterility is rare. Prevention by limitation of exposure.

Infra-Red Rays. Injuries—heat cramps, skin erythema, cataract—in foundry and furnace work, welding, glass manufacture.

Ultra-Violet Rays. Injuries—conjunctivitis, corneal ulcer, iritis—in electro-welding. Prevention by spectacles or protective glass screens.

Radium. Used in luminizing. Injuries—due to alpha or beta particles, gamma-rays, or radon—causing true radium poisoning (jaw necrosis, bone malignancy, aplastic anaemia); respiratory lesions (including cancer); aplastic anaemia; dermatitis. Prevention by legislation; Mayneord's protective container; periodic blood examinations; radon estimations of exhaled air; dental film test.

Short Waves. Exposure in manufacture of television and therapeutic apparatus. Serious risk to health improbable.

WORKING CAPACITY AFTER THYROIDECTOMY

BY

W. L. SCOTT and J. W. PARKS

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Since the introduction of improved methods of surgical treatment of thyroid disturbance—largely the result, in this country, of team work by Dunhill, Joll, Keynes, and others—the risk has been considerably lessened. Joll (1932) reported over 85 per cent. of cures, and Linnell and Keynes (1939) have stated that the great majority of patients can resume approximately normal lives.

In order to assess the working capacity of patients who have undergone thyroidectomy, 105 cases occurring amongst Post Office workers have been analysed over a period of fifteen years. The results were worked out from accurately kept sick records and not from after-histories based on the statements of individual patients which often tend to be unreliable. Although all the cases were of proved thyrotoxicosis it was impossible to separate those of primary exophthalmic goitre from others of secondary adenomatous goitre; nor was it possible to obtain information regarding the pre-operative condition, the presence or absence of complications, or the technique employed—all of which have an important bearing on the end result.

The sample consists of 38 men and 67 women. The latter were employed on sedentary work as clerical officers, telephonists, counter clerks or telegraphists, whilst seven of the men were engaged on similar duties, and the remainder on manual work as postmen, sorters or engineering workmen.

Age distribution

Table I shows the age distribution at the time of operation. It will be seen that the largest number of cases occurred in the age group 35–40 and the smallest in the 55–60 group, a steep fall taking place after the age of 50.

TABLE 1

Age group	Numbers		
	Men	Women	Total
19–25	5	12	17
25–30	2	10	12
30–35	2	14	16
35–40	10	14	24
40–45	10	5	15
45–50	6	7	13
50–55	2	5	7
55–60	1	0	1
Totals ..	38	67	105

Analysis

The cases have been analysed into two groups—those who died or retired on medical grounds, and those who are still in the service or have retired for non-medical reasons (see Table 2).

Post-operative deaths occurred in four cases—two men and two women, one of whom had valvular disease of the heart. These deaths took place in the years 1935 and 1938 in which fifty cases underwent operation, a mortality figure of 8 per cent., which compares unfavourably with the findings of Heyd (1942) who, dealing with similar numbers—108 cases between the years 1934 and 1939—reported no deaths although in his series of 106 cases between 1929 and 1934 the mortality was 6·5 per cent. Other observers in this country have reported varying mortality rates, Morley (1936) 3·7 per cent.; Linnell and Keynes (1939) 1·1 per cent.; Dobson, Seely and Rose (1942) 1·5 per cent.; but the total number of cases observed was never less than 300.

Seven of our cases failed to return to work after operation; one had thyroidectomy in 1931 and the remaining six between the years 1934 and 1939.

Ninety-four cases resumed duty after operation, but of these, thirteen, ten of whom were women, were later invalided on medical grounds after an average service of 3·2 years. Symptoms of thyrotoxicosis recurred in four cases and led to retirement, whilst two were invalided on account of melancholia, and two because of functional nervous disorders. Rheumatoid arthritis, chronic iliac strain, toxic choroiditis, chronic pelvic inflammation following hysterectomy, and hyperpiesia accounted for the remainder. Thus medical causes accounted for the loss of 20·9 per cent. of the sample within five years of the operation. Of those women who did not return to duty, or returned to duty and were subsequently invalided on medical grounds, 47 per cent., or nearly half, were over 40 years of age at the time of operation. The post-operative prognosis in women over 40 must be considered poor. It may be that the menopause has a more serious effect because of the unbalanced endocrine system due to thyrotoxicosis. The yearly average pre-operation sick rate of those invalided was 58 days and compared

TABLE 2

TABLE 2

PATIENTS WHO HAVE DIED OR RETIRED ON MEDICAL GROUNDS

Age group	No. of cases	Observation years before operation			Average days annually sick before operation	Operation deaths	Retired immediately after operation		Retired subsequently for medical causes					
							Medical cause	Operation successful	No thyro-toxicosis	Observation years after operation				Average days annually sick after
		Over 6	3–5	Under 2						Over 10	5–9	3–4	Under 2	
Males—														
20–29	1	—	1	—	2	—	—	1	—	—	—	—	—	—
30–39	2	—	—	2	96	1	—	—	1	—	—	—	1	357
40–49	4	—	4	—	23	1	1	1	—	—	1	—	—	42
50–59	2	—	2	—	24	—	1	—	1	—	1	—	—	33
Females—														
20–29	2	—	1	1	1	1	1	—	—	—	—	—	—	—
30–39	4	—	1	3	50	—	—	—	—	—	1	2	1	98
40–49	5	—	3	2	35	1	1	—	1	—	—	—	3	89
50–59	4	—	3	1	57	—	1	—	1	—	1	1	1	43

PATIENTS STILL WORKING OR RETIRED ON NON-MEDICAL GROUNDS

Age group	No of cases	Observation years before operation			Average days annual sick leave before operation	Observation years after operation				Average days annually sick after operation	Subsequent auricular fibrillation	Subsequent hyper-thyroidism
		Over 6	3–5	Under 2		Over 10	5–9	3–4	Under 2			
Males—												
20–29	6	—	2	4	34	2	2	2	—	11	—	1
30–39	9	—	4	5	9	1	7	1	—	6	1	—
40–49	12	1	9	2	11	—	12	—	—	8	2	—
50–59	2	—	2	—	26	—	2	—	—	14	1	—
Females—												
20–29	21	3	7	11	20	2	12	3	4	12	—	1
30–39	23	—	13	10	16	3	19	1	—	11	—	2
40–49	7	1	3	3	29	—	6	—	1	13	—	1
50–59	1	—	1	—	33	—	1	—	—	13	—	—

with 17 days for 55 of the remaining 68 cases who are still in the service. (As a result of war conditions it was not possible to obtain pre-operation sick records in 13 cases.) It seems that the wear and tear on the vascular and nervous systems in these cases is sufficiently serious to influence the results of thyroidectomy, and it is clear that the earlier operative measures are carried out the better.

Of the remaining cases, thirteen women resigned, eight for marriage, three to take up other work, and one to join H.M. Forces. Three of the 68 still in the service have auricular fibrillation, two have had a second thyroidectomy, one has developed pulmonary tuberculosis, and one cerebral arteriosclerosis. These cases have been under observation for from five to fifteen years following thyroidectomy. In this group it was found that recovery from operation took from five to six months, but after resumption of duty the yearly average sick rate amounted to 9·1 days for men and 9·4 for women—an average of 9·3 days per year, which is remarkably low particularly as the years of observation covered the war period.

Scrutiny of the causes of sick absence failed to reveal any salient features. In ten cases tonsillitis and sinusitis accounted for most of the absence, and Heyd (1942) stressed the importance of the part played by infections of the nose and throat in lighting up nervous or cardiac symptoms in these cases. Recurrence of symptoms of thyrotoxicosis causing temporary incapacity took place in 7·4 per cent. of the group of 81 cases, but the absences were of short duration in four of these.

An attempt was made to assess the improvement in operative methods in terms of sick absence, but the group was too small to be of any value. A total of eleven cases operated on before 1935 had an average annual sick rate of only 6·8 days, but at that time thyroidectomy was less common than it is to-day and only the less severe cases were so treated.

Conclusions

Our experience goes to show that, in the 79·1 per cent. of cases of thyroidectomy in which death or retirement did not take place, the level of subsequent health and working capacity was not inferior to that of normal individuals. The earlier the operation the better the prospects of a complete recovery.

Where prospects have to be assessed in relation to acceptance for a pension or superannuation scheme, a preliminary period of observation of at least three years after operation is advisable.

Summary

1. 105 cases of thyroidectomy in Post Office workers between the years 1929 and 1943 have been analysed; of these 4 died, 7 did not return to work, 13 resigned, and 13 were invalided on medical grounds.

2. Medical causes accounted for the death or retirement of 20·9 per cent. of the sample during the five years following operation.

3. Of women retired, 47 per cent. were over 40 at the time of operation.

4. Pre-operation sick rates were higher amongst those subsequently retired than the rates incurred by patients still in the service.

5. The average length of post-thyroidectomy service of subjects subsequently retired on medical grounds was 3·2 years.

6. The average annual sick rate of those remaining in the service has been 9·3 days per year, 9·1 days for men and 9·4 days for women.

We should like to express our thanks to Mr. A. E. Green of the Medical Department, General Post Office, for his assistance in the recording of these cases.

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SUBCUTANEOUS EMPHYSEMA DUE TO COMPRESSED AIR

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Compressed-air tools are of interest by reason of their vibratory action which affects the peripheral circulation of the fingers. Raynaud's syndrome in riveters, pneumatic chisellers and drillers is well known. The harmful effect is almost certainly due to vibration, although cooling of the hands may occur with some pneumatic tools and may be a contributory factor.*

Apart from using compressed air for riveting, burring and drilling operations, there are, however, two other widespread and simpler uses of compressed air in industry, associated with a totally different hazard. It is used as a coolant, i.e. to cool the tool on a lathe or other machine; and, more commonly, to blow away metal chips during machining so that the operator can see the work. A flexible rubber tube with a nozzle is used, rather like a small hosepipe, which most workers sling near their machine. The air pressure is about 70 lb. per square inch, which is capable of dimpling the back of the clenched fist quite deeply even when the nozzle is held several inches away. Considering its widespread use it is surprising that accidents are not more frequent; they are common enough, however, and are known to experienced industrial nurses. Several cases have come to my notice where there was skin trauma through which air entry caused subcutaneous emphysema.

A typical history is that of a healthy young man working in an aero-engine works. While milling a steel component a piece of metal pierced the pulp of the middle left finger. He removed the 'swarf' and continued to work, holding the components in his left hand while he used the compressed air on them. In a few minutes the injured finger had gone quite white. The terminal part of the finger was like 'washerwoman's finger'—white, insensitive, and slightly tense. An hour and forty minutes later he had the typical 'crackling' swelling of emphysema over the dorsum of the hand and on the radial side of the extensor surface of the forearm as far as the elbow. There was no further extension of the swelling, but the finger was then red and aching. He was sent home and the condition disappeared within twenty-four hours. Kept under observation for a few days no sepsis developed, and there were no untoward results. He lost only one shift from work.

The literature reveals only one reported case of emphysema due to a similar cause. This was recorded by Blau (1928) as a peculiar and so far undescribed injury. Skin trauma was present—a cut in the right forefinger—and compressed air was accidentally allowed to play on the wound. There were no after-effects and the emphysema disappeared within a few days. Blau found it difficult to believe that compressed air, which would have little pressure after leaving the tube, could cause the accident, but after personally handling one of these air blast tubes I have little doubt that air could enter even through a small puncture—as in the case reported above.

Pneumatic rupture of the rectum due to compressed air tools has been reported by Finnegan (1923), and subcutaneous emphysema of the hand by Parker (1937)—due to a man accidentally putting his hand over the exhaust of a pneumatic driller. In this latter case a cut was present and the emphysema disappeared in a day.

The condition is obviously allied to 'grease-gun finger' where oil is forced under very high pressure into the fingers, possibly through a lesion of the skin, and where sometimes gangrene may supervene.

Summary

Apart from its use with pneumatic tools compressed air is commonly used in the engineering industry, (*a*) as a coolant, and (*b*) to blow away metal particles from the cutting area of machine tools.

If the operator has already sustained skin trauma there is a risk of air entering the wound and causing subcutaneous emphysema. A typical case is recorded.

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* Against this is the fact that the writer has seen Raynaud's syndrome in flexible shaft polishers using a large polishing wheel at excessive speed. The wheel, which resembles a large-sized dentist's drill, caused 'white fingers' in 9–12 months in a few men who, being on piecework and inexperienced, used the electric motor at top speed. This instrument works warm, so that the harmful effect must be purely vibratory.

BRIGHTNESS, WELL-BEING AND WORK

BY

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London

I. Introduction

Seeing is a function of lighting and, since the former is immensely important for the well-being of man in general, the latter necessarily demands inclusion among the basic requisites for health, with which social, and thus industrial, medicine must concern itself.

It is true that seeing is possible in widely different conditions of lighting, but it is this very fact that leads to much abuse of the eyes, and neglect to consider and secure those conditions which are necessary for visual efficiency, as well as for general comfort and health.

There has, however, been considerable improvement in the artificial lighting of many factories during the thirty years which have elapsed since the first appointment of a departmental committee to consider the lighting of factories. During the period of the present war much has been done to bring the artificial lighting in vital factories up to desirable standards, though it is unfortunate that, at the same time, admission to them of natural daylight has been restricted, and often avoided altogether. But there is still much unsatisfactory lighting in industry, particularly, though not exclusively, in the smaller factories.

It was not until the advent of the Factories Act of 1937 that there was included among the general statutory provisions for safeguarding health one requiring sufficient and suitable lighting, whether natural or artificial, in every part of a factory in which persons are working or passing. Nearly four years later, the Factories (Standards of Lighting) Regulations, 1941, were made under Section 5 of the Act. These define some of the conditions which, for the time being, are accepted as ' sufficient and suitable,' though the regulations are, at present, applicable only to factories working more than 48 hours a week, or in shifts. There are no similar regulations enforceable in offices and other places of employment.

The distinction between sufficiency and suitability is conventional, and in some respects convenient, but, clearly, no lighting can be entirely suitable for any given purpose unless it is also sufficient. What is meant by the expression ' sufficient lighting ' is merely the *amount* of light, or the illumination, which ought to be provided on the work so that it can be done without straining the eyes, and the amount of light which ought to be provided elsewhere in the factory for convenience and safety in passage about the premises. On the other hand, the expression ' suitable lighting ' is used to cover a number of factors—some quantitative and some qualitative—such as diffusion and direction of the light, the placing and screening of light sources to avoid troublesome shadows and glare, and the spectral composition of the light. But, of course, sufficiency and suitability, as thus defined, are both essential for good lighting, and quantitative standards of illumination, when specified, are only valid when other conditions of lighting are suitably arranged.

II. Brightness and Illumination

The object of all lighting is to give *brightness* to external objects, whereby they become visual stimuli capable of exciting a sensation to which the term brightness is also applied. Physical, or stimulus, brightness is something which can be measured photometrically. Objects have this brightness either because they emit light directly, as in the case of electric lamps, or because they reflect some of the light they receive from the light sources illuminating them. It is usual to express brightness in candles per square inch, the *candle* being the unit of *luminous intensity*. The current Factory Lighting Regulations restrict the permissible brightness of any part of a light source or lighting fitting which is visible to persons employed within 100 feet of it to ten candles per square inch, unless the source is mounted more than 16 feet above the floor, or the angle of elevation from the eye to the source exceeds 20 degrees. This brightness is appreciably greater than the average brightness of the day sky.

The brightness of a surface which reflects light depends on the nature of the surface, the illumination it receives, and the angle from which it is viewed. Polished surfaces, which reflect light regularly, may have a brightness in a particular direction almost equal to that of the sources illuminating them. Matt surfaces reflect light diffusely and may present almost the same brightness in any direction of view. Brightness, in this case, is proportional to the product of the illumination of the surface and its *reflection factor*, the latter being simply the ratio of the light flux the surface reflects to that which it receives. The reflection factor depends on the colour of the surface, and also on the ' colour ' (wave length composition) of the light illuminating it. It is quite common to express the brightness of diffusely reflecting surfaces in *equivalent foot-candles* or, synonomously and preferably, *foot-*

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lamberts. (These units are converted to candles per square inch when divided by 452·4). The term 'equivalent foot-candle' is derived from the unit of illumination which, in Britain and America, is the foot-candle, and, since brightness depends on illumination and reflection factor, it is not surprising that a term based on the foot-candle should have come into use for expressing brightness values, though photometrists prefer the alternative 'foot-lambert.'

The *foot-candle* itself is the illumination a surface has when it receives unit quantity of light flux per square foot. And, as the unit of light flux is called the *lumen*, it follows that an illumination of one foot-candle is equivalent to one lumen per square foot. If a given light source, such as an electric lamp, emits a thousand lumens (units of luminous flux) and, with the aid of a suitably designed reflector, 70 per cent. of this flux be uniformly distributed over a surface one square foot in area, the surface is given an illumination of 700 foot-candles, or lumens per square foot. If the surface is white, having a reflection factor of 0·8, its brightness is then $700 \times 0{\cdot}8 = 560$ equivalent foot-candles; but if the surface is very dark in colour, having a reflection factor of 0·06, its brightness is only 42 equivalent foot-candles. As it is only the brightness, and not the illumination, which the eye appreciates, it will readily be understood that the reflection factor of the objects we wish to see has a most important bearing on the illumination that must be provided.

Illumination can be measured, with sufficient accuracy for factory purposes, by means of a simple photo-electric photometer giving a direct reading of the foot-candle value at any point where the instrument is placed. In measuring the illumination on the work which is being done in a factory, office, or elsewhere, it is, of course, essential to place the light-sensitive plate of the photometer in the position normally occupied by whatever the worker has to see, and the measurement should be made with the worker in his usual position so that the instrument takes into account the effect of any shadow he may cast on the work. Instruments of this type are affected by the colour of the light used. They are usually calibrated for the light given by tungsten filament lamps, and correction factors are given by the makers to be applied to readings taken in light of different colour quality. The correction for daylight is small, and can usually be neglected.

It will be understood, from what has been said above, that measurement of the illumination available does not, of itself, indicate whether or not the lighting is adequate for its purpose. Such measurements must be considered in relation to the nature of the illuminated objects, and the dependence of the eye to see them upon the *brightness* stimuli it receives. As already explained, a high illumination may mean only a low brightness if the work illuminated has a low reflection factor. The brightness of the work cannot be measured so simply as its illumination, but can be derived approximately from the latter if the reflection factor of the work is estimated by matching it with one of a series of samples whose reflection factors are known.

In the case of daylight, the illumination anywhere inside a building can, of course, be measured with a portable photometer as described above. Daylight illumination varies, however, over a wide range during the course of each day, and also with the seasons. It would, therefore, be necessary to make a large number of measurements at different times of the day and year in order to obtain an average value for the daylight illumination at any particular point. This difficulty is avoided by measuring the *daylight factor* at the points of principal interest, e.g. individual work places. The daylight factor is simply the fraction (usually expressed as a percentage) of the illumination available outdoors, from the whole hemisphere of sky, which reaches the point under consideration inside a building. It is determined by measuring, simultaneously, the illumination at the chosen point in the building and that outside at a point exposed to the diffuse light from the whole sky. Thus two observers are required. It is a convention, in this country, to assume an outdoor illumination of not less than 500 foot-candles for the purpose of deciding what will be a satisfactory daylight factor in any given case, i.e. what factor will ensure adequate interior illumination during a reasonable proportion of the annual hours of daylight. On this basis, it is evident that any point having a daylight factor say of 1 per cent. will usually have an illumination of not less than 5 foot-candles. This value will be exceeded whenever the outdoor illumination is more than 500 foot-candles, and at times, particularly in the summer months, the interior illumination at such a point will reach 25 or 30 foot-candles.

III. Factors Affecting the Amount of Light Required

Although, strictly, adequacy cannot be abstracted from suitability as an aspect of lighting, it will be convenient to treat it as separable, with the proviso made in the introduction. Accordingly, we shall deal first with the question, how much light is necessary for the eyes to meet the demands made of them in industry ?

Any particular kind of work can be seen under widely different amounts of illumination, though it cannot be seen with the same ease, certainty, and speed over the whole effective range. Small needles can be threaded all day in the light of a candle giving only a few units of illumination—providing we do not mind how slowly the work is done, how much effort is wasted in unsuccessful attempts, how much the eyes ache and burn at the end of the working day, or how irritable we become, and how disinclined, or unable, we are to use the eyes for such leisure pursuits as reading. The same task can be done near a window in daylight, but with very different results. Here there may well be more than a hundred units of illumination available on the work. If it were done out-of-doors this illumination might be multiplied tenfold, and this would not be harmful, though it might be more than is really needed to do the work as well as possible, and with the least fatigue.

For every task in industry for which the eyes are used there is a minimum illumination, with which visual perception of the work is only just possible, and an optimum illumination, beyond which no apparent advantage may be gained. Between these extremes the gap is wide, and for some industrial operations the real optimum is never reached indoors, even in daylight. It is only the optimum illumination with which management and preventive medicine ought to be concerned, and to make the question posed above more explicit it must be asked —how much light is required to promote good

health, comfort, and safety, and thus to be consistent with the maintenance of a high standard of industrial efficiency? The answer involves the consideration of a number of factors, some physical, some physiological, and some psychological.

(a) *Analysis of the Visual Task*

In the first place, the physical characteristics of the objects of vision are involved, in so far as they affect the amount and quality of the light passed on, or reflected, to the eyes when the objects are illuminated. All objects absorb some of the light they receive and reflect the rest, either diffusely in all directions, or regularly in a direction depending on that from which the incident light comes. Hence, of course, white and black objects, which reflect very different fractions of the light they receive, must have very different illuminations to give them equal brightness, as already explained in section II. Also, there must be a difference of brightness, or colour, or of both, if an object is to be distinguished from others adjoining it and forming its 'setting.' This difference, or contrast, may have to be accentuated, or created, by providing different amounts of light on adjacent objects or parts of an object which, owing to their similar properties of reflection, would not otherwise be discriminated.

The physical dimensions, and distance from the eyes, of the work objects are of great importance in relation to the amount of illumination required, since these determine the size of the retinal image and the acuity of vision called for. Another physical variable, in some industrial tasks, is motion, and this affects the illumination required if details of the moving objects need to be clearly discerned.

These are characteristics of the work which can be measured, though not always easily, nor with great precision. As yet, there has been no systematic attempt to do this as carefully as it might be done, and so to obtain the most exact data from which to deduce the visual capacity required, and the necessary conditions of lighting. 'Diagnosis,' of the task is clearly the necessary preliminary to the prescription of a proper dose of illumination. Also—as in medical practice—the diagnosis will be more precise and reliable the more completely the physical 'signs' are observed and subjected, as far as possible, to actual measurement.

In making this diagnosis, or assessment, of the task, it is important to remember that the 'critical' detail that has to be seen is not always a permanent feature of the work-objects. It may exist only momentarily, being created in the course of the action of the worker upon his materials—as in assembly, when two parts are being brought into connection. The familiar task of threading a needle, already mentioned, is a case in point. Here it is not the size of the eye of the needle which is the smallest detail to be seen, but that part which is seen when the thread is so positioned that penetration can be successfully accomplished. Similarly, in assembling the pivots of the moving coil for small electrical measuring instruments, it is not the complete hole into which the pivot has to be inserted which determines the fineness of visual discrimination required. It is the size of that fragment of the hole by which the worker sees that the final act of pushing home the pivot can be proceeded with, without risk of missing the goal and damaging the adjacent delicate wire On the other hand, in some inspection processes, a fixed feature of the objects scrutinized constitutes the critical detail, and there should be no difficulty in measuring its size and the contrast it presents with its immediate surrounds. The analysis of tasks to determine the operations involved is already widely practised in the pursuit of industrial efficiency, and their analysis and measurement for the purpose of setting standards of vision and lighting is no less necessary.

(b) *Effects of Variation of Illumination*

(i) *Noticeable Differences.*—In the case of sight, as of the other special senses, the least noticeable difference of stimulus is a function of the stimulus itself, i.e. it is not a constant quantity but a constant fraction of the stimulus intensity. This is broadly true within limits of intensity which cover the range of illumination levels necessary in factories, as will be seen from Fig. 1.

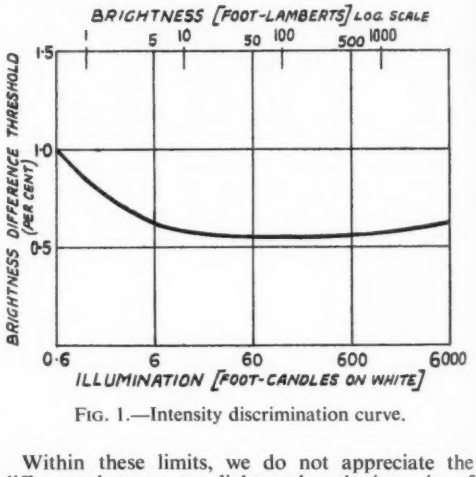

FIG. 1.—Intensity discrimination curve.

Within these limits, we do not appreciate the difference between two lights unless the intensity of one differs from the other by at least a certain percentage, which does not vary and determines the size of the smallest discrimination step. It is the *ratio* of the two intensities, and not the arithmetic difference between them, upon which our experience of their unlikeness depends. Hence, successive equal increments of illumination become progressively less effective and, eventually, become relatively too small to make any appreciable difference. This is readily illustrated by switching on the artificial light in a room at twilight and again in broad daylight. In the first case, a very distinct improvement in the illumination is noticed, but in the second, the same additional amount of light—being only a small instead of a large fraction of that already present—makes little or no noticeable difference.

Thus, if we have the problem of effecting a similarly noticeable improvement in the brightness of two rooms, one of which already has a low and the other a high illumination, the same *proportional* increase in the existing illumination should be made in each case. The result will not be achieved by the addition of the same number of foot-candles to the illumination in each room. This principle is of fundamental importance in lighting practice.

(ii) *Visual Acuity.*—It is brought out again when

we consider the relation between illumination and visual acuity. Lythgoe (1932) has shown that visual acuity is proportional to the logarithm of the brightness, or corresponding illumination, of the object, and that it improves up to a level of illumination exceeding 1200 foot-candles, providing the surroundings are also adequately illuminated. Thus, successive equal proportional increments of illumination are necessary to produce equal arithmetic increments of visual acuity, and so to enable correspondingly smaller detail to be seen. Fig. 2 shows the relation found by Lythgoe.

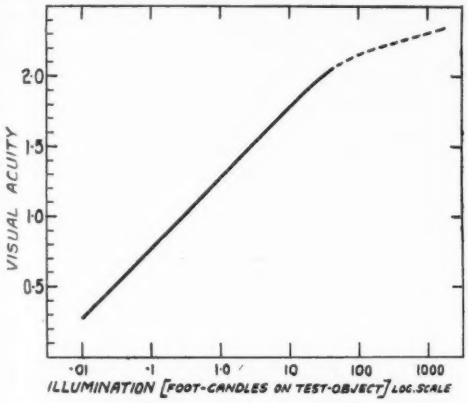

FIG. 2.—Variation of visual acuity with illumination (Lythgoe).

Visual acuity is expressed as the reciprocal of the angle visually separable, and the minimum acuity required for any industrial task can be found if the dimensions of the detail that must be seen and the distance of the objects from the eyes are measured. The minimum illumination necessary could then be derived from Lythgoe's relation, but is of no interest as a practical standard, being merely sufficient to give a slightly better chance of seeing than of not seeing the critical detail. What is really required is sufficient illumination for rapid, certain vision, and it is, therefore, necessary to know how visual performance improves when illumination is raised above the liminal value.

(iii) *Illumination and Size of Detail.*—Investigation of the variation of visual performance when illumination is thus increased has shown that the minimum illumination for a task presenting a given size of detail must be very greatly exceeded in order to obtain the greatest ease and speed of seeing. This is shown by the curves of Fig. 3, which are plotted from data obtained by Weston (1935). The task studied involved continuous visual inspection, and presented detail ranging in visual size from 1 to 10 minutes, i.e. demanding a minimum acuity ranging from 1, (V = 6/6), to 0·1, (V = 6/60). It will be seen, for example, that the task requiring at least so-called 'normal' acuity (V = 6/6) can only be done with maximum efficiency if the illumination is more than a thousand times the value with which this acuity is just possible.

From Fig. 3 it is also seen that as the fineness of the work increases (i.e. size of detail decreases), the illumination required to maintain the same level of relative performance increases in much greater ratio.

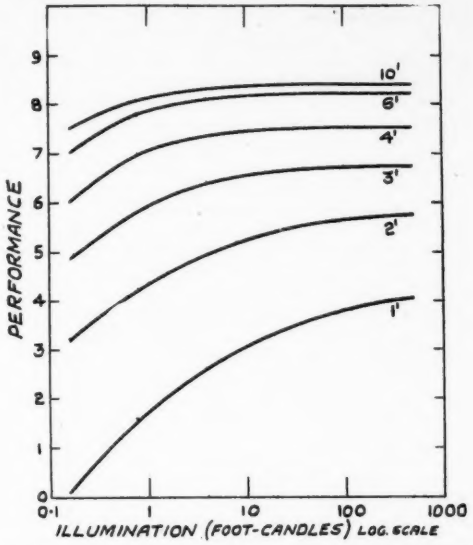

FIG. 3.—Variation of performance with illumination and size of detail requiring discrimination. Size is given in minutes of arc subtended at the eye by critical detail of the object. From this family of curves values of illumination can be found such that relative efficiency in performing tasks differing in size, between the limits shown, is independent of size.

Considerable changes of illumination are needed to bring about small changes of acuity. It follows that if the size of detail that has to be seen in any practical visual task can be varied, a given enlargement is much more effective in easing the task than

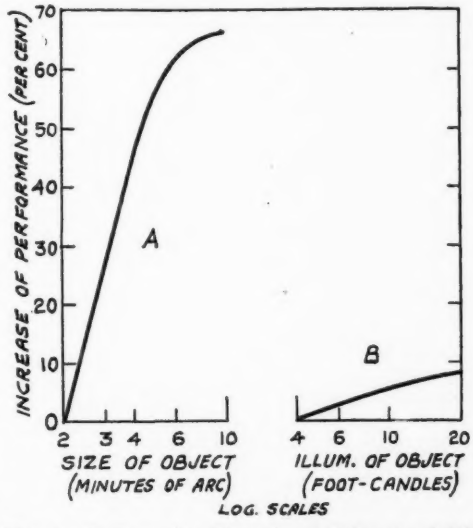

FIG. 4.—A shows the effect of magnifying size 5-fold (from 2 to 10 mins.) illumination being constant at 4 foot-candles. B shows the effect of magnifying illumination 5-fold (from 4 to 20 foot-candles), size being constant at 2 minutes.

is a similar proportional increase of its illumination. This is clearly shown by Fig. 4.

Usually the physical size of the objects to be seen is fixed, but the apparent size of these can be varied by varying their distance from the eyes. This, of course, is what is done when illumination is inadequate. By bringing the eyes nearer to the work its apparent size is increased until it is brought within the restricted visual capacity. The near point limits the extent of the enlargement obtainable in this way, and, as a method of compensating for lack of light, shortening the viewing distance is frequently responsible for the development of accommodative asthenopia, and for fatigue due to the posture the worker may have to adopt.

However, it is not generally realized how much the illumination may have to be improved to avoid viewing the work so closely that accommodation and convergence of the eyes is greater than can be sustained with comfort. Suppose, for example, a person engaged on fine work—say fuse assembly—finds it necessary, with the prevailing illumination, to view the work at a distance of only nine inches. As ten inches is usually regarded as about the shortest comfortable distance of the eyes from the work, how much must the illumination be increased to maintain the visibility of the work while giving the worker the benefit of the additional inch ? Now if the viewing distance is thus increased in the ratio 10/9, the apparent size of the detail that has to be seen will be reduced in the ratio 9/10, i.e. it will be 10 per cent. smaller. It has been shown elsewhere (Weston, 1943) that this necessitates an increase of illumination of about 40 per cent. If the working distance were lengthened to eleven inches the apparent size of the detail would be reduced by about 18 per cent., and the illumination would need to be nearly doubled. These conclusions are in accord with practical experience, and receive support from the earlier work of Lythgoe (1932) already referred to. To obtain the higher illumination required to lengthen the working distance by one inch might mean, e.g. replacing a 60-watt lamp by one of 75 watts (giving about 30 per cent. more light) and placing it a little nearer the work. Alternatively, the distance of the 60-watt lamp from the work might be reduced by 15 per cent. To lengthen the working distance by two inches the size of the lamp would have to be increased from 60 to 100 watts, or the 60-watt lamp be placed 30 per cent. nearer the work.

(iv) *Illumination and Contrast in Task.*—The differentiation of objects within the field of vision depends essentially upon the contrast of brightness or colour between them. A particular contrast of light and shade, or its equivalent when the contrast is that of black print on white paper, or a grey pattern on a different grey ground, is completely defined in physical terms by the two objective brightness values involved. It is, however, the ratio and not the difference of these values which determines the degree of contrast, i.e. whether it is ' strong ' or ' weak,' ' high ' or ' low,' in the scale of physical brightness contrasts. And it is also the ratio of the contrasting stimulus brightnesses which chiefly determines the sensation of difference, or contrast, experienced, and the relative ' goodness ' of different contrasts as appreciated by the eye. Thus, the contrast between two high brightnesses, whose ratio is low, is a poor one as compared with that between two much lower brightnesses whose ratio is high, even though the arithmetic difference between the first pair is larger than that between the second pair. For example, the contrast between two slightly different shades of grey paper is poor compared with that between pieces of black and white paper, and remains so even if the greys are highly and the black and white poorly illuminated, i.e. even if the difference of brightness presented by the greys is made greater than the difference between the black and white.

The degree of brightness contrast presented by such surfaces, or by self-coloured but textured surfaces, can, however, be modified by the conditions of lighting. These may be arranged to provide a selective distribution of light, or to take advantage of the properties of reflection of particular objects so as to enhance or diminish their brightness in the usual direction of view.

Subjectively, however, degree of contrast does depend partly on the difference as well as the ratio of the brightness stimuli involved. Thus, if a grey pattern on a slightly lighter or darker grey ground is suitably illuminated the pattern can be seen, although the contrast between it and its background may be very poor. If the illumination is gradually reduced a point is reached when the pattern disappears. In this case the brightness ratio of pattern and ground is not altered. But the *difference* of brightness between pattern and ground is reduced in the same proportion as the illumination, and becomes smaller than the eye can detect.

Above a certain level of brightness, or illumination, the contrast sensitivity of the eye does not continue to improve, i.e. the poorest contrast that can be appreciated requires that the brightnesses involved shall bear to each other a minimum ratio which is constant, whether the actual brightness values are near to or considerably above the level at which maximum sensitivity is reached. This can be seen from Fig. 1.

But the speed and thus, presumably, the ease with which all supra-liminal contrasts are perceived improves as the brightness of the two components of the contrasts, and therefore their difference of brightness, is raised to a much higher level. This is true for contrasts as encountered in the majority of common visual tasks where the recognition of detail is involved. Fig. 5 illustrates this effect, each curve showing the relation between illumination and the performance of a simple visual task involving perception of detail of constant size but different degree of contrast.

The poorer the contrast the lower the performance. But, whatever the contrast, performance improves with illumination and this improvement is relatively greater for poor than for good contrasts. Thus, a pencilled note on white paper is less easy to read than a similar ink-written note when both are seen under the same illumination—say 3 foot-candles. The visibility of the pencilled script, relative to that of the ink script, will be improved if both are seen under higher illumination—say 30 foot-candles; and the respective visibilities will differ still less if the ink note is illuminated to 3 foot-candles while the pencilled note is given 30 foot-candles.

It was suggested by Beuttell (1934) that the best method of compensating for inferiority of contrast might be to adjust illumination in such a way that the *difference* of brightness between the contrasting

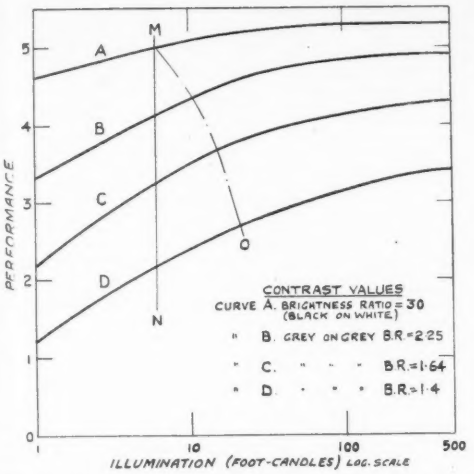

FIG. 5.—Variation of performance of a visual task with contrast and illumination. The line M–N is drawn at 6 ft./cs., and its intersection with each curve indicates the performance obtained at this illumination with each contrast. The curved line M–O intersects each curve at a point corresponding with the illumination at which that contrast will present the same brightness difference as the best contrast does at 6 ft./cs. The change in performance should be noted. Size of detail in the object was 3 min. in each case.

elements which reveal the important detail in a visual task would have the same value for all degrees of contrast. This value would be that found to give satisfactory visibility of detail of the given size when the contrast by which it is seen is the best possible, (Theoretically, perfect black—reflection factor = 0, and perfect white—reflection factor = 1·0).

From an experimental study of the variation of visual performance with contrast and illumination, Weston (not yet published) found that when the illumination of visual tasks involving different degrees of contrast is so chosen that the brightness difference presented in each contrast is the same (i.e. is independent of the degree of contrast) the visibility of the different tasks still varies directly with the contrast, though their relative visibilities are less disparate than under conditions of illumination such that poor contrasts present a lower brightness difference than good contrasts. Nevertheless, subject to certain limitations, Beuttell's rule for 'correcting' illumination according to the contrast presented in the visual tasks is a useful one.

If, however, the contrast by which the detail of objects is revealed can be improved by modifying the material objects themselves, a change in this respect may be a much more effective aid to vision than a similar relative change of illumination. Such modification is often possible in practical industrial tasks. The immediate background of objects to be inspected, and the materials of which the objects are made, or at any rate their surface colour and finish, are often open to choice, and it is sometimes only tradition and habit which prevents the exercise of this choice in favour of good visibility.

Fig. 6 deals with a simple case, and shows that if the ratio of paper and print reflection factors (a measure of contrast) in a visual discrimination test is multiplied, say tenfold, by substituting black print on white paper for grey print on a slightly different grey paper, the speed and accuracy of visual discrimination is greatly improved without any increase of illumination. If, however, the poorly

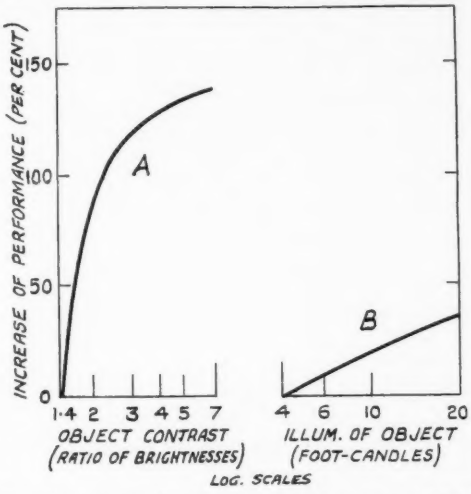

FIG. 6.—A shows the effect of magnifying contrast 5-fold (from B.R. = 1·4 to B.R. = 7), illumination being constant at 4 foot-candles, and size constant at 3 mins. B shows the effect of magnifying illumination 5-fold (from 4 to 20 ft./cs.), contrast being constant at B.R. = 1·4, and size constant at 3 mins.

contrasting greys are retained, but their illumination is multiplied tenfold, the resulting improvement of performance is relatively small.

Hence, whenever the materials and dimensions of the work objects are not imposed upon the designer or manufacturer by more important considerations, they should be chosen with due regard to the severity of the visual task they will create for the worker, and the illumination this will demand. As 'a stitch in time saves nine,' so a small enlargement of size or contrast, when this is feasible, may save a lot of light—and eyestrain.

(v) *Illumination and Industrial Performance.*—A number of investigations have been made, in this and other countries, to determine the relation between illumination and the performance of workers in different industries. The effect of variation of illumination upon output has also been observed incidentally in the course of factory studies primarily concerned with other environmental factors. In general, it can be said that the results of most of these studies show the need for higher values of illumination than those current when the investigations were made. In some cases they suggest the optimum illumination for processes of certain classes, using quantity and quality of output as the criteria.

Thus, Elton (1920) showed that the output of silk weavers during the first two months of the year rises steadily as the daylight illumination increases, and the duration of artificial lighting decreases. From data relating to the variation of daylight during this period, it can be inferred that the optimum illumina-

tion for the work considered is not less than about 30 foot-candles. Weston (1922) showed the effect of inadequate daylight, and also artificial light, on the output of linen weavers, and Wyatt (1923) observed an increase of about 5 per cent. in the efficiency of cotton weavers when adequate daylight was available instead of the low illumination (little more than 1 ft./c.) available by artificial light. Weston (1938) also studied the effect on output of varying the illumination provided for worsted

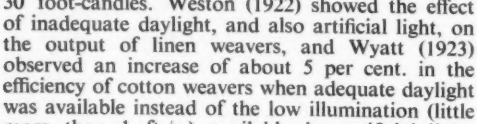

FIG. 7.—Variation of output with illumination in typesetting by hand.

weavers, working entirely by artificial light, and concluded that the optimum value on the cloth (medium coloured suitings) is of the order of 30 ft./cs. With this illumination the personal efficiency of the weavers, as distinguished from the weaving efficiency measured in terms of machine running time, was 24 per cent. better than with rather less than half the amount of light.

The effect of illumination on the quantity and quality of output, in a fairly fine industrial process,

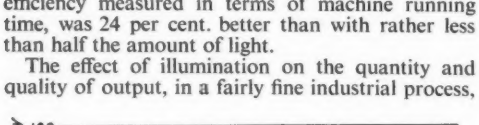

FIG. 8—Variation of accuracy with illumination in typesetting by hand.

is very clearly shown in the results of a study of typesetting, made by Weston and Taylor. These results are represented in Figs. 7 and 8.

It can be seen from Fig. 7, that, within the limits of illumination considered, the relation between amount of work done and the illumination provided is of the same kind as the relation which holds between visual acuity and illumination, i.e. the work done increases by equal increments for equal *proportional* increments of illumination. At about 24 ft./cs. the output of work is equal to that done in good daylight. Fig. 8 shows that the proportion of mistakes in the work done decreases as the illumination increases, and here again the daylight norm is reached at 24 ft./cs.

Though it has not been possible to make strictly valid comparisons between output before and after the improvements in illumination which have been effected in many factories during the war, some managements have been able to make rough assessments of the gain probably due to better lighting. Of those known to the author, most are reasonably consistent with expectation based on pre-war investigations dealing with changes of illumination of similar magnitude.

(vi) *The Effect of Movement.*—It is well known that if a clear image of moving objects is to be obtained, the illumination must be better than it need be for seeing stationary objects. And, for any given rate of movement the illumination required will depend upon the factors already considered, namely, size, and contrast. As the rate of movement increases, the time during which the stimulus provided by the object acts upon any retinal receptor decreases. Thus the response of the receptors must be speeded up, otherwise the effect of one stimulus will not be fully developed before another is applied, thus causing the visual images to be blurred. Flicker experiments show that the response of the cones is speeded up, i.e. their reaction time is reduced, as illumination is increased but, of course, however high the illumination is made there is a minimum below which this reaction time cannot be reduced. It is difficult to express this in terms of rate of movement of objects which have to be discriminated in motion during factory processes. The matter is complicated by the fact that the eyes can often follow the moving object, and so keep its image nearly stationary on the retina. When this is not possible flicker experiments suggest that, within limits, as the rate of movement is increased arithmetically the illumination must be increased geometrically. However, the effect on the illumination required, due to relative movement between eye and object, has not yet been adequately studied under practical conditions. At present, therefore, the illumination for processes involving discrimination of moving objects must be determined on the basis of their static characteristics, with an arbitrary allowance for movement, or must be found empirically in each case.

(c) *Psychological Considerations*

Bad lighting is necessarily an obstruction to normal visual activity and, for this reason, occasions disagreeable feeling. This varies in intensity and distinctness according to the extent and nature of the unwanted restriction imposed on visual experience, and it may be modified by recognition of justifying, or extenuating, circumstances for this restriction. It is, however, augmented and heightened by the feeling of strain aroused by organic sensations accompanying ocular adjustments which are made in more or less ineffectual efforts to overcome the impediment. In the extreme case—as described in one of Poe's tales *—the feeling is of 'eyes straining from their sockets.'

* The Pit and the Pendulum.

There is no doubt that the disagreeable feeling thus aroused by strain in seeing, and the imperfection and limitation of the visual impressions received, affects the higher emotional life. It is quite sufficient to induce annoyance and bad temper or depression, which, if prolonged, or frequently experienced, passes into a settled mood through which the general outlook is distorted. The mental soil is then well prepared for any other seeds of discontent to germinate and flourish with weed-like proliferation. Moreover, this state of mind is easily carried over into extra-industrial life, and in this way the 'sins' of the factory may be visited upon the family, or have still more remote undesirable consequences. Of course, this is equally true whatever factory condition, or conditions, may be the exciting cause, but this in no way lessens the potency of lighting in this respect.

One of the effects noted during the war in blacked-out factories, where artificial light has been very unevenly distributed, and substantial areas of semi-darkness intervene between workplaces, is the sense of isolation which workers tend to experience. They feel almost cut off by gloom from visual intercourse with their fellows, and with their surroundings, so that the team spirit and the corporate life of the group tends to be weakened, and the social urge thwarted.

Even, however, when there is no noticeable sense of strain in seeing either the work itself, or the contents of the wider visual field which are of general interest, lighting may have little or no positive psychological value. It is, of course, well known that excitation of the senses is pleasurable up to a certain point and, until this point is reached, the degree of pleasure increases with the strength of the stimulus. The sense of sight affords no exception to this rule, and the pleasure accruing from visual stimulation is enhanced by values of the stimulus which may much exceed those which suffice for satisfactory visual scrutiny of the work-objects themselves, when these involve no small detail. The most familiar demonstration of this truth lies in the universal experience of apparent enhancement of the *vis vitae* experienced on clear bright days, for which there are many colloquial expressions—such as 'feeling on the top of the world'—and the feeling of subnormal vitality on days that are cloudy and relatively dull. The illumination on both occasions may be adequate for easy seeing, but the superior pleasure of the former is undeniable. 'Truly the light is sweet, and a pleasant thing it is for the eyes to behold the sun.' These epigrammatic words from Ecclesiastes express a profound truth, of which too little account is taken in much industrial lighting practice. And the degree of vitality and pleasure we feel on bright days does not result merely from that satisfaction of our sense of congruity given by knowing that the sun is not masked, but is due, at least in part to the intensification of visual excitation by the higher prevailing brightness.

Thus, providing there is no glare (*vide infra*), psychological considerations suggest that, when engaged in industrial activity, and irrespective of our specific needs for the particular task involved, the more light we have the better we *like* it. And this is true up to a level of several hundred foot-candles, such as may be had near a large window for some hours on an average bright day.

That the variation of feeling associated with sensory stimulation may be correlated with muscular activity is well known, and a general statement of this relation is to be found in any account of the psychology of feeling. Wundt puts it succinctly—'a feeling of joy and excitation makes movement easy and prompt; a depressing feeling renders it slow and heavy.' * While personal experience has doubtless convinced us all of this—so that to state it explicitly is perhaps to be trite—its importance in connection with lighting is often unappreciated, judging from many examples of current industrial practice. Experimental evidence of the motor response to light stimulation is available, however, and Fig. 9 shows that rate of movement may con-

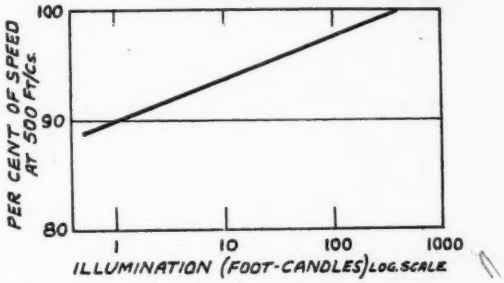

FIG. 9.—Illumination and rate of working in an easy visually guided hand operation.

tinuously improve as illumination is raised up to the level suggested above.

This graph refers to a group of subjects performing a simple cancellation test in which the objects to be marked were large enough for the speed of visual recognition to be nearly independent of illumination, over the range shown, so that the slope of the curve is chiefly due to variation of the rate of arm and hand movement. This effect appears to vary—as does the acuity of the eye—with the logarithm of the illumination, i.e. it grows by equal steps when the stimulus follows the 'law of organic growth.' But, since it is evident that the change in rate of activity is small compared with the variation of illumination required to produce it, values of illumination of a much lower order than the psychologically optimal can be used without serious detriment. This is fortunate, because the reproduction of daylight intensities in general lighting by artificial sources would be costly, and not always easy to achieve without glare and undue heat. Moreover, though there is no evidence that such intensities are not just as pleasurable with artificial as with natural light, providing other important characteristics of the lighting are equally satisfactory, we do not demand such high values of illumination, when daylight is not expected, in order to satisfy our sense of congruity.

Nevertheless, the minimum level of illumination required to maintain a psychologically satisfactory brightness environment exceeds the average value provided by artificial light in many factories even to-day.

Failure to provide this minimum occurs most frequently in factories, or parts of factories, where the tasks performed obviously do not require high

* Wundt, W., *Human and Animal Psychology*.

degrees of visual capacity. In such cases the work may be seen well enough with a low level of illumination, which is not infrequently provided by local lights at actual workplaces, leaving the general environment to be illuminated by stray and reflected light. This is the result of a superficial view of the purpose of factory lighting, whereby it is considered to have only one essential function—namely that of illuminating the work.

It is, of course, only with reference to the average factory that it is possible to suggest a single value of illumination as the psychological, or 'amenity,' minimum. Since it is brightness with which we are really concerned, it is clear that this average value will be too low for factory interiors which are abnormally dirty, or have their structural surfaces, fixtures and plant painted in dark colours. Conversely, though it will not be too high for unusually clean factories with light-coloured decorations, it may be somewhat reduced if economy in lighting is a serious need.

The actual value of this minimum for the average factory can be put at about 6 ft./cs. With this value it will be seen on reference to Fig. 9 that the rate of working of the group studied is about 93 per cent. of the rate recorded at the highest illumination used, viz.—500 ft./cs. It seems reasonable to expect that lighting shall be good enough to permit a standard of efficiency of this order. But Fig. 9 is based on tests made in a laboratory having light decorations, though the conclusion reached is supported by the results of observations by Adams (1935)—made over a much longer period of time—of the output of persons engaged on rough work (tile-pressing)—in a factory. Fig. 10 gives a smoothed

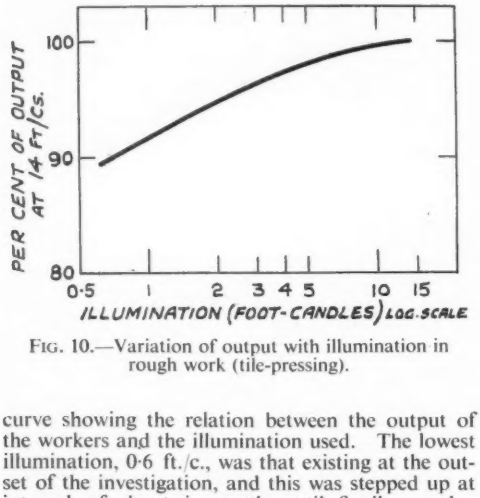

FIG. 10.—Variation of output with illumination in rough work (tile-pressing).

curve showing the relation between the output of the workers and the illumination used. The lowest illumination, 0·6 ft./c., was that existing at the outset of the investigation, and this was stepped up at intervals of about six months until, finally, a value of 14 ft./cs. was used.

Though—to use a picturesque phrase of William James'—'the trees don't grow into the sky,'* it appears, from the curve, that the growth of output did not reach its ultimate limit with the highest illumination tried. Thus, although the output at 6 ft./cs. was about 98 per cent. of that at 14 ft./cs. its relation to the possible maximum output is probably in closer agreement with the figure obtained from Fig. 9.

From consideration of the available evidence, and of demonstrations of the brightness produced by different illuminations under conditions found in factories, the Departmental Committee on Factory Lighting (1940) reached the conclusion that 6 ft./cs. should be recommended as the legal minimum illumination in working areas, at any rate in wartime when it is of vital importance that environmental conditions in factories should favour the maintenance of a high standard of health and efficiency. This value is specified in the Factories (Standards of Lighting) Regulations, 1941, made by the Minister of Labour, and is applicable (subject to certain exemptions) to all factories working 48 hours a week or more, or on shifts.

IV. Illumination Codes

Scientific investigation of the illumination required has, so far, been limited to only a few of the great variety of industrial operations involving vision. The processes studied have, however, usually been selected as being apparently representative of many others, which can be classified as falling within one or other of a few broadly defined categories, e.g. rough, fine, very fine work. To the extent that results of actual investigations are available, they can be used as the basis upon which to found recommended orders of illumination for each such type of work. But, as stated earlier in this paper, there is, as yet, a lack of precise data, derived from analysis and measurement of particular industrial tasks, by which these may best be classified, or the illumination they require may be found synthetically from general relations existing between illumination and the principal factors involved in perception of the work. However, accumulated data relating to actual industrial lighting practice and, in particular, those obtained from organizations whose practice is dictated by the greatest concern for welfare and efficiency, afford an empirical basis for a scale of illumination levels applicable to the wide range of industrial processes. And these processes can be ranked or graded roughly—by persons of suitable experience—according to the difficulty of the visual task they present. The result is a catalogue of processes divided into sections, to each of which there corresponds an appropriate part of the illumination scale.

It is mainly on this basis that current illumination codes rest and, because they do so, they must necessarily be subject to revision from time to time, as fresh knowledge and experience leads to more accurate appraisal.

In this country, an illumination code is issued by the Illuminating Engineering Society (1942) and, in its current form, has set the standards adopted in the lighting of vital factories during the war. Its scale of values and classification of tasks is reproduced below.

It may be noted that the scale of values is not equally divided and, in fact, the means of the successive ranges form, approximately, a geometrical series. The need for this has, it is hoped, become apparent from the discussion in section III. Weston (1943) has proposed certain modifications of this code to establish it on a more fundamental basis, but these are concerned mainly with the regularization

* *The Energies of Men.*

and extension of its scale, and the more precise grading of tasks.

I.E.S. Recommended Values of Illumination for Various Tasks

	Foot-candles	*Class of Task*
1.	Above 50	Precision work to a high degree of accuracy; tasks requiring rapid discrimination.
2.	25/50	Severe and prolonged visual tasks; discrimination or inspection of fine details of low contrast.
3.	15/25	Prolonged critical visual tasks, such as proof reading, fine assembling, and fine machine work.
4.	10/15	Visual tasks such as medium machine and benchwork, and sustained reading.
5.	6/10	Less exacting visual tasks, such as casual reading and large assembly work.
6.	4/6	Work of simple character not involving close attention to fine detail.
7.	2/4	Casual observation where no specific work is performed.

While the I.E.S. code is not mandatory, attention is drawn to it in the 5th Report of the Departmental Committee on Factory Lighting as forming a valuable guide to the illuminations required for special classes of work. In Australia, a closely similar code has recently been adopted as the basis for legal minimum requirements in factories. In general, American recommended values of illumination are higher for all classes of work, and no value lower than 5 foot-candles is recommended. This scaling-up of recommended values means, of course, that a somewhat higher standard of results is aimed at than is the expectation on which the British recommendations are based. Indeed, it is important to point out that the latter must not be regarded as values which cannot be exceeded with advantage. That something is to be gained by adopting better standards has, in fact, been stressed in the preceding section III (*c*), while, in certain factories, it is now a breach of the Factory Lighting Regulations to provide less than 6 foot-candles over working areas. Moreover, this minimum is without prejudice to any additional illumination required by the nature of the work, and the provision of such higher illumination where necessary is now obligatory.

V. Individual Differences in Light-need

The standards of illumination derived from investigations of the kind discussed in this paper, as well as those obtained by analysis of current good practice, are values suitable for 'average' persons. But it must be borne in mind that for various reasons, individuals differ widely among themselves in the amount of light they need to do a given task comfortably and efficiently. Inherent differences in the optical and neural apparatus for seeing, acquired defects from injury or disease, and the inevitable differences due to the age of the eyes—as well as other factors—all produce a considerable spread about the average. Thus a considerable proportion of a factory population may require more, or could manage as well with less, than the code recommended illumination for average persons and the given class of work. A by no means negligible fraction may apparently see as well as 'average' people with much less light; others may require much more. It is most important to recognize this fact in dealing with the lighting of fine work and Weston (1944) has drawn attention to the fact that, for an equal performance of such work, the illuminations required by different individuals in an unselected group may range between extremes which are in a ratio of the order of 100 to 1.

Moreover, the relative efficiency of individual workers doing the same job, i.e. their value as producers with reference to the best of them, is, in part, a function of illumination. This means that as the level of illumination is raised—while the efficiency of all the workers improves—the proportional gain is greater for the inferior than the superior workers, so that the former tend to catch up with the latter. This effect is illustrated in Fig. 11, and, of course,

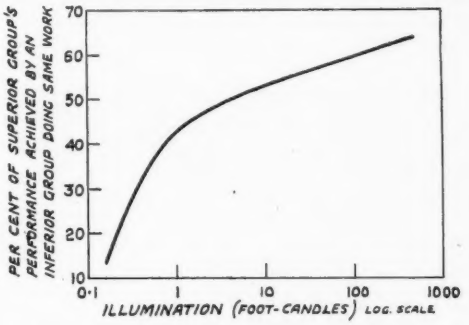

Fig. 11.—Effect of illumination on inequality of capacity among persons doing fine work.

it is clear that the maximum efficiency of a non-homogeneous group of workers can only be secured when conditions are optimal for the worker whose light-need is greatest. In practice, it is common to provide persons doing fine work with adjustable lighting units, and it should occasion no surprise to find that persons doing similar work arrange these individually to give widely different illuminations.

VI. Maintenance

The values of illumination required by law in factories, namely those applicable to working areas, and the minimum of half a foot-candle specified for all other interior parts over which persons employed are liable to pass, are those which must be maintained. Therefore, in planning the lighting of a factory, higher initial values must be arranged for, so as to allow for normal depreciation in service, which must occur with the accumulation of dust and dirt on windows, lamps, and fittings, and with the ageing of artificial light sources. The values recommended for the work, in lighting codes, are service values and, to maintain them, regular cleaning is essential at intervals which must be determined by local conditions.

VII. Factors Affecting the Suitability of Lighting

In addition to the amount of light required, which has been dealt with in some detail in the preceding sections, there are other important factors upon which the suitability of lighting for work depends. In the present state of our knowledge some of these must be discussed chiefly in descriptive rather than quantitative, terms.

(a) *Distribution of Light*

It should never be forgotten that the function of lighting in the factory is to brighten the general environment of the worker, and not only the objects to which his visual attention must be specially directed in performing his given task. It is the whole-man whose needs must be satisfied, for the work-man is surely nothing less than this. If we choose to call him workman when he clocks-in at the factory, let it be remembered that he does not, at the same time, clock-out any of his normal susceptibilities. He sees the factory and sees it whole—whether he wants to or not; and all the visual sensations and perceptions which arise from his environment, as well as his work, and are items in the inventory of his experience, have some influence on the general tone of feeling. Even when attending to objects of special interest we are not unaffected by visual impressions received from the surrounds. They enter into our ' marginal awareness ' and form part of the subconscious experience which affects our sense of our general condition. As Ward puts it, ' they tell on conscious life as sunshine or mist tells on a landscape, or the underlying writing on a palimpsest.' * Moreover, as Stout points out, ' their subconscious presence is a condition which favours their emergence into distinct consciousness. . . . If my attention flags in reading my book, I may begin to notice a candle-flame. The visual sensations, which had previously been subconscious, cease to be subconscious, and become separately discerned, yielding at the same time a distinct apprehension of the candle-flame.'† Thus in the factory, where visual preoccupation with the work is by no means continuous, there are many opportunities for visual sensations excited by the general surrounds to break in upon distinct consciousness. The distribution of an adequate amount of light in *all* directions in the factory, is plainly necessary if these sensations are to promote cheerfulness. Such a distribution is usually achieved with daylight in modern factories in uncongested areas, especially factories of single-storey structure with roof windows. It is one of the reasons why daylighting is universally preferred to artificial factory lighting of the most prevalent types. While the trend of recent practice in artificial lighting has been towards the distribution of a better share of light to parts of the factory other than the working plane, it has become very evident, during the war, that artificial lighting, as it still exists in many factories, is psychologically unsatisfactory. The upper parts of workshops are frequently unduly dark, giving what has become known as the ' tunnel effect,' and making the light sources themselves too conspicuous and obtrusive. Where the latter are mounted at a relatively low height, and provided with opaque reflectors directing all the light in a downward direction, the work itself may be well lighted but a large area of the general field of vision is left almost black. Much of the rest of it may also be of low brightness, if the machines are painted in the conventional dark colours, and heavy shadows are cast on the floor. These conditions are by no means uncommon and are very depressing. Weston (1941) has described such a case, in which the factory was known to the workers as ' the dump,' and, in the words of one of them—whose breakdown seemed imminent—' the tendency among the younger ones is just to look forward to knocking-off time . . . and sink into a " fed-up " attitude to the rest.' A considerable improvement in this factory was effected by installing additional lighting units, to illuminate parts of the interior above the level of the work lights.* A typical example of a light distribution planned without proper regard for the general appearance of the interior, and concentrating only on the working plane, is shown in the accompanying photograph, Fig. 12.

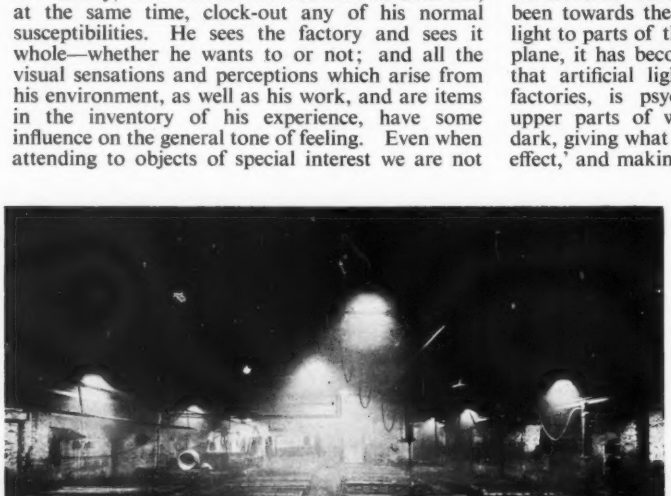

FIG. 12.—Light distribution badly planned, concentrating only on working plane.

Recognizing the importance of a bright and cheerful appearance of the factory, the Departmental Committee on Factory Lighting (1940) recommended that, throughout the interior parts of factories where persons are regularly employed, parts of walls, partitions, ceilings, tops of rooms, inside of windows where daylight is obscured and, as far as practicable, other structural fixtures which are less than 20 feet above floor-level shall be maintained light in colour. This recommendation has not been embodied in any statutory regulation, but its implementation is most desirable, and would enable satisfactory general brightness to be achieved with the greatest economy of light.

* Ward, James, *Psychological Principles*, p. 94.
† Stout, G. F., *Manual of Psychology*, p. 134.

* Illustrations of this factory appear in the pamphlet, ' Heating and Ventilation, Lighting and Seeing,' recently issued by the Industrial Health Research Board and published by H.M.S.O., 1943.

On the physiological side, an adequate brightness of the general field of view is important for the functional efficiency of the eye. Lythgoe (1932 ; 1936) has shown that acuteness of vision only continues to improve up to high illuminations providing the surrounding field of vision is also adequately illuminated. This appears also to be true for other visual functions which have been investigated. Both on psychological and physiological grounds it is thus a principle of good lighting that the brightness of the surrounding field of vision should not differ greatly from the brightness of the work, nor should the brightness of the general field of vision be very patchy. It is clear that, apart from the depressing effect of dark surroundings on the feelings, and on visual functions, they involve an appreciable change of adaptation every time the gaze is shifted from the work to the surroundings. If this shifting of the view occurs frequently, it is likely that, for a substantial portion of the time spent in the factory, the eye is not fully adapted to either level of brightness it encounters.

The different methods of distribution of artificial light are classified as direct, semi-direct, general, and indirect. In the direct method it is usual to employ enamelled steel reflectors which re-direct all upward light from the lamps in a downward direction. It is thus an economical method of lighting the work, and for this reason is most extensively used. But, as already pointed out, it secures good illumination below the fittings, while above them the interior is left relatively dark, since it only receives light indirectly after reflection from the floor, workbenches, and lower parts of walls. If the latter are dark in colour, or dirty, very little light indeed may reach the upper parts of the workshop. Where such an installation is used, it is often desirable—though rarely done—to install some lighting units for the special purpose of brightening the roof and upper parts of the walls.

The semi-direct method achieves this object fairly well, either by the use of translucent, or prismatic, glass reflectors, or by steel reflectors partly open at the top, thus allowing some fraction of the direct light from the lamps to be distributed in the upper hemisphere. In the method of general distribution, enclosing fittings of diffusing glass are used, and these allow the light to be distributed in all directions. For obvious reasons they are not very suitable for use in some factories, and are actually used only in a few. Their use in offices is far more widespread. The indirect method is difficult to apply in many factory buildings and, for a given illumination on the working plane, it is the most costly method of lighting. However, it can give excellent results, in respect both of appearance of general brightness and visibility of the work. It is a suitable method of lighting rooms devoted to such operations as gauge inspection, since the resulting brightness is very uniform, and fine detail on polished metal parts, e.g. scales and verniers, is most easily seen.

(b) *Effects of Glare*

(i) *Direct Glare.*—Glare is always present when there are areas within the field of view whose brightness greatly exceeds the average brightness of the field. It is, therefore, largely a matter of brightness contrast. Thus, the filament of a bare electric lamp, which has a brightness of some thousands of candles per square inch, is a source of glare if it is visible to anyone whose eyes are adapted to the general level of brightness of the whole field illuminated by the lamp—which may be only a few foot-lamberts (equivalent foot-candles). It is unnecessary to instance other examples of conditions causing direct glare, since they are very familar, and are, unfortunately, very prevalent in industry.

It has been shown, e.g. by Stiles (1929), that the brightness difference threshold is raised, i.e. the contrast sensitivity of the eye is lowered, by the presence of a glare source in the field of view, and the magnitude of this effect varies inversely with the angular separation of the glare source and the line of vision. Stiles expressed the glare effect in terms of the background brightness of the field of view which, in the absence of the glare source, would correspond with the reduced contrast sensitivity. Put in another way, the effect of the presence of a visible glare source is to reduce the effectiveness of a given illumination on the work, so that, to be equally visible, the latter needs a higher standard of illumination than is necessary when glare is absent. Thus glare is wasteful, in that it discounts the value of a given standard of illumination, so that it yields disappointing results, or, alternatively, involves additional expense in providing higher illumination. It has already been pointed out in section III that the standards of illumination embodied in any lighting code must be based on the assumption that other conditions which affect the suitability of lighting will be satisfactory. They are strictly valid only when this is so, and one of the conditions assumed is the absence of glare.

Two forms of glare are generally recognized, namely, disability glare, which temporarily impairs vision, and discomfort glare, which is more or less unpleasant but does not appear to interfere with the performance of the eye. Both types of glare are still common in industry, but the second is perhaps most widespread, and is often not recognized as such, since its effects tend to be general rather than specific, and may be attributed to other causes. It seems likely, as Harbinson and Bartlett (1934) have suggested, that the discomfort associated with glare is partly a function of the task rather than of the glare stimulus directly. But this means that the more difficult is the task the more important is the avoidance of glare. So far as disability glare is concerned, the need for its avoidance should require no emphasis. Not only may it interfere directly with production, but it may be an actual source of danger to workers, since it can result in failure to see some obstacle, or other object, in consequence of which the worker suffers injury.

Unfortunately, there is at present no simple means of measuring the glaring properties of a lighting installation, such as we have for measuring the illumination it provides. In this respect then, appraisal of an installation is a matter of judgment based on experience, and of a due appreciation of the factors involved in the causation of glare. However, rules have been suggested for the avoidance or limitation of glare, and these include the restriction of the brightness of the light sources, and of their location with respect to the eye, the restriction of the volume of light reaching the eye directly from any light source, and the specification of a maximum ratio of brightness of source to brightness of surrounds. From consideration of daylight conditions,

it has been suggested that the latter should not exceed 100 to 1, a value which is much lower than is usually found under conditions of artificial lighting.

As mentioned in section II, the Factory Lighting Regulations attempt the control of glare by setting a limit to the permissible brightness of any part of a light source or fitting which is visible within an angle of elevation of 20 degrees from the eyes of any person, while normally employed within a distance of 100 feet from the source, unless the latter is mounted at a height of more than 16 feet above floor-level. The specified limit of brightness is 10 candles per square inch and, like all such limits embodied in legal requirements, it does not represent the ideal condition, being only intended to protect the worker from exposure to unreasonably bad conditions. The really desirable maximum brightness of lighting units, visible as described, is probably not more than half, or better still one-quarter, of the statutory maximum. Compliance with the regulation for the control of glare, or the achievement of more comfortable conditions than this will secure, involves the use of suitably designed and installed lighting equipment. In the case of a local light, which is defined as any light so placed as to illuminate part, or all, of the area of work of a single operative or small group of operatives working near each other, the light source must now be completely screened from the eyes of every person employed at a normal working place.

It is, of course, quite possible to experience glare in daylight, if work is done facing a window. A small window is usually more troublesome in this respect than a large one, because its brightness may greatly exceed that of the surrounding wall surface which is its background and which may receive no direct daylight.

(ii) *Glare by Reflection.*—Glare is very frequently caused by the reflection of bright light sources in polished surfaces, which may be those of the work material, or of parts of machines and metal fixtures, or walls finished with high gloss paint. It is often very annoying and troublesome, and increases the difficulty of the work and the fatigue of the worker.

Wyatt and Langdon (1932) have observed the effects of glare, due to reflection, on the performance of women examining cartridge cases. The workers complained that the electric light produced a disturbing dazzle from the brass caps of the cases, which made the task of inspection more difficult and fatiguing than they found it in diffuse daylight. Fig. 13 shows the effect of this dazzle on the rate at which two of the inspectors were able to do the work.

The reduced rate under artificial light means a fall in output of about 6 per cent., and it is very likely that a similar effect occurs in many factories where the same method of artificial lighting by concentrated high brightness sources is used for work with specular material.

It has been mentioned already that indirect lighting is very suitable for illuminating work of this kind, since the effective light sources are of large area and low brightness, so that their reflections in polished material are not dazzling. But other methods are also satisfactory, such as lighting by means of luminous panels or other secondary light sources of low brightness, or by means of fluorescent tubular lamps. Some such method should, in fact, be used in factories to which the current statutory lighting regulations apply, since it is required that

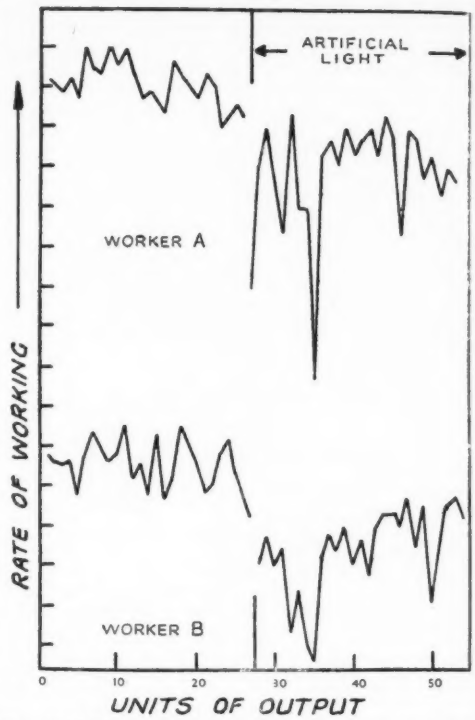

FIG. 13.—Reduction of rate of working, due to dazzle from the work caused by unsuitable artificial lighting.

'so far as reasonably practicable, arrangements shall be made, by suitable screening or placing or other effective method, to prevent discomfort or injury by the reflection of light from smooth or polished surfaces into the eyes of the worker.'

(c) *Diffusion and Shadow*

The presence of dense shadows in factories is generally unpleasant and sometimes very inconvenient, or even dangerous. To avoid them a considerable degree of diffusion in lighting is necessary, such as is usual in daylight. With artificial lighting the greatest diffusion is obtained by the indirect method, by which all the light from the lamps is thrown on to the ceiling and then reflected in all directions throughout the interior. Such a high degree of diffusion is not necessary for most industrial processes, and is definitely undesirable for some in which the presence of detail in the work is revealed mainly by the formation of shadows. The texture of self-coloured materials, such as textile fabrics, and the detail of many other three-dimensional objects is seen partly by means of shadows, but even in these cases the degree of diffusion which is usual in the daylighted factory appears to be generally satisfactory. The general, semi-direct and direct methods of artificial lighting provide—in the order given—lesser degrees of diffusion.

In the case of type-setting by hand, an operation where shadows play some part in rendering the detail of the type visible, Weston and Taylor (1928)

found the direct method of lighting gave the best results, though there was little to choose between this and semi-indirect or even indirect lighting, and none of these systems of artificial lighting gave better results than natural daylighting. Weston (1938) studied the effects of different methods of lighting for weaving. One of the installations tried provided strongly directional light coming from one side of the looms, so as to accentuate the contrast between the warp threads by giving them a high brightness on one side while the other was shadowed. The effect on the performance of the weavers was not significantly better than that of a conventional direct system of lighting giving about the same illumination on the working plane. This result is not in agreement with that reported by Goldstern and Putnoky (1931).

Lighting from a particular direction is, however, certainly valuable in some cases for the purpose of casting shadows which can facilitate the perception of detail. It is also often necessary in order to get adequate illumination on particular objects, but local light sources can generally best be used for this purpose. Owing to the structural characteristics of machinery, the presence of overhead gear, materials racks and so on, the avoidance of disturbing shadows over parts of the working area is not always easy, and calls for skill and experience in planning the lighting installation. It is now obligatory however that 'adequate measures shall be taken, so far as reasonably practicable, to prevent the formation of shadows which cause eyestrain or risk of accident to any person employed.'

(d) '*Colour*' *of Light*

We naturally take the apparent colour of objects illuminated by daylight as their normal and expected colour quality. But, as is well known, the light emitted by most artificial sources now in common use differs in composition from natural light, though the latter is not itself constant in this respect. This difference affects the apparent colour of objects as seen in artificial light, and it is a familiar fact that accurate matching of certain colours cannot be done in ordinary artificial light. Unconsciously, however, we make allowances for the effect of lights which do not greatly differ in 'colour' from daylight, so that we can accept the appearance of many familiar objects illuminated by them as being natural in colour. Accordingly, for all ordinary purposes it is found that lighting by gas lamps or electric filament lamps is satisfactory so far as its rendering of colours is concerned. Discharge lamps, in which the light is produced by the electrical excitation of gases or vapours, emit light only in certain regions of the spectrum. Although, on this account, the apparent colour of familiar objects illuminated by them is considerably changed and made obviously unnatural, experience seems to show that the visibility of some classes of work, e.g. in engineering machine shops and foundries, is not adversely affected. It has, in fact, been claimed that mercury and sodium discharge lamps improve the visibility of work of this kind, but there appears to be no adequate evidence for this. Many workers seem readily to adapt themselves to the altered—and certainly, at first, the unpleasant—appearances due to these types of light source, but the author has found none who actually prefers this to more natural lighting.

To improve the colour characteristics of high-pressure mercury discharge lamps they have been modified by enclosure in an outer bulb having, internally, a coating of fluorescent powder. This transforms some of the invisible ultra-violet radiation emitted by the lamp into visible light, which makes good some of the deficiency in red which is characteristic of the bare lamp emission. Lamps of this kind are now extensively used in factories. They are efficient sources of light, but are only a little better than the plain mercury discharge lamps, so far as colour rendering is concerned. Another method of securing better colour characteristics is to use both plain mercury discharge lamps and tungsten filament lamps together. Either two lamps—one of each kind—can be used in each fitting or reflector, or the two light sources are available combined in a single bulb.

Much more natural colour rendering is now obtainable with the use of what is known as the white, or colour 'A,' 80-watt fluorescent lamp. During the war many of these lamps have been installed in factories, particularly in those from which daylight is permanently excluded. They are low-pressure mercury discharge lamps in tubular form, internally coated with a mixture of fluorescent powders, by means of which the ultra-violet light from the discharge is very effectively converted into visible light. In composition this closely resembles the natural light available on a summer day. The characteristics and applications of these lamps are fully described by Atkinson (1944).

There can be no doubt that the introduction of such lamps has made possible a great advance in the artificial lighting of factories, whereby so close an approach to natural conditions can be achieved that the common prejudice against working for long periods by artificial light can usually be overcome. Not only is the colour of the light very satisfactory, but the brightness of the lamps is relatively low, so that glare is less likely to be experienced. The tubular form of the lamps is also an advantage for many applications.

In a considerable number of factories, even in peace-time when no part of the window area is permanently and intentionally obscured, daylight does not penetrate to a substantial part of the working area in sufficient quantity for the work. It has, therefore, to be supplemented all day by artificial light, but this is unnoticeable when it is done by fluorescent tube lighting.*

The accompanying photograph, Fig. 14, while it cannot show the daylight colour appearance of the factory given by fluorescent lighting, shows that the fluorescent tube is well suited to an arrangement of light sources which is in itself less obviously artificial than conventional arrangements of small concentrated light sources. The tubes are mounted end to end in continuous troughing and this, in conjunction with their colour and moderate brightness, tends to the impression that the factory is lighted by narrow overhead windows.

Some approximation to the colour quality of daylight can be obtained by using various corrective devices, e.g. colour filters, in conjunction with

* At present the installation and use of this, and all forms of discharge, lighting is controlled under S. R. & O., 1943, No. 1201. The Minister of Works is unlikely to grant the necessary licence for the use of fluorescent lighting except in cases covered by a War Emergency Code of Practice on the Limitation of Electric Discharge Lamp Lighting prepared by the Institution of Electrical Engineers.

FIG. 14.—Fluorescent tubular lighting.

ordinary tungsten filament lamps. As some of the light radiated by the lamps is subtracted by these devices and converted into heat, it is relatively costly to obtain so-called artificial daylight by their use. For very accurate colour matching, however, special lamps are required which provide light of a standardized colour quality.

It must be added that there is no reliable evidence that ordinary artificial lighting, e.g. gas or tungsten lighting, is physiologically undesirable on account of its colour quality, but for most people there is little doubt of the psychological value of natural or simulated natural lighting.

(e) *Stroboscopic Effects of Discharge Lighting*

In their fourth report (1938), the Departmental Committee on Lighting in Factories referred to the fact that cases still occur of fatigue and danger arising from the use of flickering or inconstant light sources in factories. They, therefore, recommended that the use of such sources should be prohibited, but this recommendation was not intended to apply generally to electric lamps, either of the filament or discharge type, operating on an alternating current supply having not less than the usual frequency of 50 cycles per second.

There is no perceptible flicker in the case of tungsten filament lamps operating on the usual 50-cycle supply, since the thermal inertia of the filament prevents the light output from fluctuating noticeably. In any case, as there are two fluctuations per cycle, the frequency is well above the critical frequency at which flicker disappears for the light-adapted eye. With a moving object it is possible, however, to observe a stroboscopic effect, and use is made of this in a simple device for checking the speed of gramophone turntables. This consists of a disc, having the necessary number of radial lines, or spokes, which, when observed by tungsten lighting on the rotating turntable, appears to be stationary if the speed of rotation is correct. Stroboscopic effects due to tungsten lighting from a 50-cycle supply appear to be of rare occurrence in the factory.

In the case of electric discharge lamps, the luminous arc is actually extinguished 100 times a second when the lamps are operating on a 50-cycle supply. Consequently, the periodic variation of illumination is much greater than with filament lamps, though the fluctuations are too rapid for flicker to be apparent when looking at the lamp, or at stationary objects illuminated by it. An effect akin to that of flicker may, however, occur when moving objects illuminated by discharge lamps are observed. Such an object, being illuminated intermittently, may appear to move in a jerky manner, or if the moving object is a rotating one, such as a spoked wheel, its apparent speed may be faster or slower than its true speed, or it may appear to be at rest.

These effects may be disconcerting, uncomfortable, and, in some circumstances, dangerous. There are, however, several methods by which they can be minimised so as to be generally unobjectionable. One method consists in mixing tungsten lamps with discharge lamps in the intallation, but this is not the most suitable method if discharge lamps of the fluorescent tubular type are used. The other methods are concerned with the location and circuit arrangement of the lamps. Their object is to ensure that any workplace receives its illumination from two or three lamps which are arranged to be out of phase, so that when the illumination from one lamp is falling that from the adjacent lamp is rising. In this way the variation of illumination on the work is reduced. With fluorescent tubular lamps there is some after-glow from the powder during the periods of extinction of the arc, and this also tends to render stroboscopic affects less noticeable. But, when single lamps of this type are used, they may be found unsuitable for the illumination of some industrial operations, or be disliked by some persons.

VIII. Colour of Decorations and Machines

Some reference has already been made to the importance of light coloured surfaces within the factory if the interior is to present a bright and cheerful appearance. Given identical factory buildings having similar fenestration and installations for artificial lighting, it is evident that the visual impressions their occupants receive will depend on the colours of the structural surfaces and fixtures which make up the visible environment. In spite of equal lighting, one factory may look grim and forbidding —as the 'dark Satanic mills' of which Blake wrote— while another of the same kind may look bright and inviting. The difference is a matter of colours and their brightness factors, or luminosity values. Some industrial processes are dirty, and it is, presumably, for this reason that dark-coloured decorations and dark-coloured machines are often found in factories where they are carried on. But dirty

work is a better reason for the choice of light than of dark colours. Even a dirty light colour is brighter than a dirty dark colour, and dark colours do nothing to encourage cleanliness.

Agricultural machines, which are used out of doors, in full daylight, are customarily painted in bright and gay colours, yet the machines of many indoor industries are commonly finished in black or other dark colours, though they receive far less light. The sum of human cheerfulness would be increased if the traditional practice in these two cases were interchanged. But there seems no good reason why the practice of the oldest industry should not become that of the others. It is true that where the importance of cleanliness is most obvious, e.g. in food factories, including dairies, light coloured decorations and machines are often found but, in factories generally, there is much room for improvement in this respect.

But the achievement of agreeable brightness is not, of course, the only consideration which should influence the choice of colours in the factory. Colour contrast is a most valuable aid to vision and, in the absence of brightness contrast, is the only means by which visual discrimination is possible—'all that is properly perceived by the visive faculty amounts to no more than colours with their variations, and different proportions of light and shade.' * With the aesthetic value of colour we are not primarily concerned in this paper, but it is neither wise nor necessary to disregard it in the pursuit of good visibility.

Some interesting colour experiments have recently been made in engineering shops, both here and in America. In one large machine shop in the Home Counties all the machines have been painted pale cream, certain small parts, which must be readily distinguishable, being treated in other colours which are harmonious but in good contrast, e.g. the electrical control boxes are painted orange. Materials racks are painted a pleasing green. The walls and stanchions, above a three-foot dado, and also the roof, are also painted cream, while the dado itself is green. The conditions for seeing are excellent, and on entering the shop from a neighbouring untreated one having the usual mass of black and battleship-grey machines, one is instantly aware of an almost dramatic favourable change of feeling. The light paint on the machines has proved as serviceable as the traditional dark colours, and the operatives take pride in keeping it clean. They have facetiously called the shop 'the dairy'—an appellation as significant of its value in promoting health as is the contrary significance of 'the dump' mentioned earlier in this paper.

Elsewhere, similar transformations have been effected and welcomed. Nelson (1943) has recently described a colour scheme planned by him and applied to part of a large Midland engineering works. An idea—though necessarily an inadequate one—of its agreeable effect is given by the accompanying photograph (Fig. 15) for which the present author is indebted to Dr. Nelson.

In America, Denning and Brainerd (1942) have experimented with the colouring of machines with the object of facilitating visual discrimination by means of colour contrast. The expression 'three dimensional seeing,' which has been used in connection with their work, arises from the suggestion that discrimination is assisted by a 'stereoscopic' effect given when suitable contrasting colours are used and appropriately disposed. For example, an object in colour contrast with its background may also appear to 'stand out' from it if the colours are suitably chosen. Goethe observed some such effect, and explained it on the basis of the spatial ideas associated with colours as observed in nature—'as we see the high heavens, the distant mountains blue, a blue surface appears to recede before us. . . .' On the other hand, the complementary colour, yellow, and colours of longer wavelength tend to 'advance.' The chromatic aberration of the eye has also been invoked to account for this effect, though whether it really appears, in the absence of other visual presentations suggesting perspective, may be doubted. Inasmuch, however, as certain colours excite preferential attention they may, in this sense, be said to stand out.

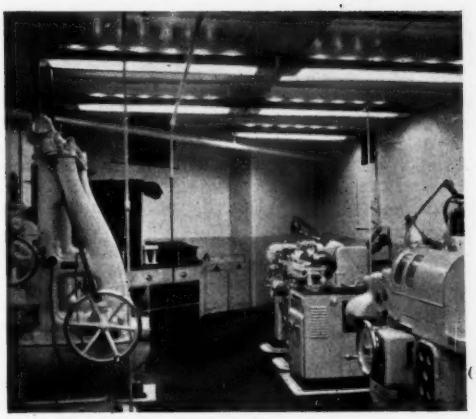

FIG. 15.

As to their effects upon feeling, Goethe classified colours as positive and negative—the former including red, orange, and yellow, and the latter green, blue, and violet. The positive, or active, colours are stimulating; the negative, or passive, are restful, subduing or depressing. But this aspect of colour cannot be discussed at length here, nor can the subject of harmony of colour, for which, as Helmholtz pointed out, rules cannot be stated with the same certainty and precision as for the consonance of tones.

In colouring the factory, however, strongly saturated colours should not be used for extensive surfaces. Pastel shades not only have the advantage of a high brightness factor, but are too weak in hue either to fatigue the colour sense or violently offend individual taste. It is not necessary to paint all the machines in a shop exactly alike. Uniformity in this may be preferred, as giving an orderly appearance, but variety, without motley, can be achieved by varying the shade but not the colour quality used for different machines, or by using different unsaturated colours for banks of different machines. As the apparent colour of paints is affected by the nature of the light in which they are seen, the kind of artificial lighting in the factory must be taken into

* Berkeley, *A New Theory of Vision*, CLVI.

account, especially in selecting what is to be the prevailing colour. For example, light which is deficient in red, e.g. the uncorrected light of mercury discharge lamps, gives a yellow surface rather a sickly hue. Sodium lighting distorts most colours, e.g. red appears as chocolate. Where tubular fluorescent lamps are used colour rendering is almost natural, but slightly 'warmer' tints than the daylight choice may be used. The room illustrated in Fig. 15 has fluorescent lighting, and the colour scheme is 'pale cream' for the walls with 'eau de nil' dado, and 'Portland stone' for the machines.* The skirting round the walls and machines is dark green and the ceiling is white. Thus, the luminosity value of the light reflected from the surfaces which occupy most of the field of view is of a high order. Matt or 'eggshell' rather than high gloss finishes should be used, as far as possible, to avoid glare by reflection.

In the case of bench work, seeing conditions can often be improved by providing a background contrasting in colour with the work material. The latter itself should be selected for easy seeing whenever there is some freedom of choice.

IX. Lighting for Safety and Hygiene

Little has been said in preceding sections concerning lighting in relation to the prevention of factory accidents, but the standards of lighting required by the statutory regulations now in force have specific reference to the safety of workers.

In the strict sense an accident is an event due to pure chance, but many so-called accidents are undoubtedly events whose occurrence could be averted if our senses served us as well as they might. On this account, it can be said that the better the conditions of factory lighting—up to the point of maximum efficiency of vision—the better the insurance against accidents. It certainly cannot be assumed that the conditions of lighting which cheer and enliven us, and are consistent with a high standard of industrial efficiency, are better than those desirable for safety at work.

It is known that daylight, even in the absence of direct sunlight, is bactericidal, but this effect has been regarded as due to its ultra-violet components. Only a little of the near ultra-violet radiation penetrates through ordinary window glass, and probably all of this is filtered out by two thicknesses of glass. In spite of this, Garrod (1944) has recently brought forward evidence suggesting that diffuse daylight, i.e. visible daylight, has some bactericidal action and, on this account, is to be regarded as a hygienic safeguard. Garrod's observations were made in hospital wards, and showed that the effect depends on the strength of the light, since it varied with distance from the windows. Possibly the relative energy of parts of the spectrum also varied with distance, owing to selective absorption in the atmosphere. Nevertheless, as the effect appears to be due to visible light, it must, if confirmed by further observations strengthen the case for good artificial as well as natural lighting in factories. For the purpose merely of revealing the presence of dirt and dust—which harbour bacteria—and of encouraging cleaning, the need for good factory lighting is too obvious to require emphasis here.

* These are standard colours, specified in B.S. 381, 1930, issued by the British Standards Institution. The brightness factor and colour equation is given for each scheduled colour.

X. Conclusion

The design of good factory lighting, whether natural or artificial, is the business of the illuminating engineer and the architect. But, while it is for them to understand and exercise the practical art of lighting—so as to fulfil the requirements which physiological and psychological considerations show to be necessary for a proper standard of well-being—it is not only for them, but clearly also for the industrial medical officer, to know what those requirements are. It is only with the latter that this paper attempts to deal, even in outline. It is hoped, however, that it may assist those whose special function it is to promote in people at work healthy minds in healthy bodies, to assess conditions of lighting as they find them in the factory, and to point out in what respects improvement may be required.

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A NEW OUTLOOK

The future of industrial medicine depends on stimulating the interest of those now entering the profession by good teaching of the subject. Although education in this subject comes mainly by experience—the method by which most of the present industrial medical officers have learned their job—there must also be planned schemes of training. Recent expansion of health services in industry found those responsible for medical education unprepared. Apart from providing occasional week-end courses universities were unable to satisfy the demand for knowledge. Now is the time therefore to attempt to meet the needs and demands of the future, and it is a matter for regret that industrial medicine has been ignored by the Government's White Paper on a National Health Service and is barely mentioned in the Report of the Inter-Departmental Committee of Medical Schools.[1] Others, however, have shown greater foresight, and chairs and departments of industrial health may shortly be set up at certain universities situated in industrial areas. It is an interesting fact that the University of Toronto has instituted a Diploma in Industrial Hygiene (D.I.H.), the course for which occupies one academic year and is open to any graduate of an approved medical school.[2] The development of a department of industrial health is a matter for careful thought, and the wise director will start slowly. The pattern will differ in different parts of the country, but there are three common underlying principles. A university department must teach not only students and doctors, but nurses and welfare workers, managers, and engineers; it must direct research into local problems; it must disseminate knowledge and be a centre of information.

Teaching will be concerned largely with conditions that promote healthy working; with the broad aspects of prevention of incapacity caused by ill-health and accidents; with the medico-social problems within an industrial community; and with the causal factors of absenteeism, studied specifically in different occupations and groups of workers. Above all it must be practical in nature, and to this end the goodwill and co-operation of employers, who control the entry of doctors and research workers into factories where teaching and research must be done, is vital. In our present system the teaching of medicine is centred in the medical schools attached to the larger hospitals. The potential industrial medical officer must have a sound knowledge of general and preventive medicine and the principles of accident surgery. But the ordinary industrial doctor is mainly concerned with the application of the principles of preventive and social medicine to the workers in his factory, and to this end he should be taught. He has to learn, for example, how treatment and rehabilitation are concerned with the needs of an individual worker, his home, his job and his wages, and not only with a particular injury or illness. The problem of industrial health is not so much one of hospital medicine as of 'non-hospital' ill-health, a much greater cause of incapacity for work: it calls for a study of the normal, so-called healthy, individual and his responses to the varying stimuli of occupation. In the future these aspects should be dealt with in training the medical student for his qualifying examination; and they must be co-ordinated into courses of post-graduate education for those who wish to devote their life to the practice of industrial medicine.

The successful teacher will be he who encourages and directs research. In industrial medicine he must carry out field work in the factory, mine, or ship-yard, and to do this he will have to obtain the confidence of the workers. Academic isolationism must be avoided: it would be the downfall of any new venture. Industry is itself severely practical; it exists by its efficiency, which depends in turn on planning for production. The employer tends to measure the value of any ancillary service by its effective contribution to the maintenance of efficiency and health at work. In this connexion the work of the Industrial Health Research Board, described in this issue by its Secretary, Dr. R. S. F. Schilling, is of much importance. The development of the Board from 1918 onwards is something without parallel in other countries. Its researches cover an extensive field and the knowledge produced tends to promote good health, contentment and efficiency, when applied within any industrial concern. The Board's work has greatly increased as a result of the war, but the health problems to be solved in time of peace will demand even greater effort. The amount of money spent on industrial health research is small compared with expenditure on other branches of industrial research; but money alone is not enough. We must find, and train, suitable men and women to act as teachers and investigators. While independent effort is essential, there is need for integration if wasteful and uninformed research is to be avoided. The day may not be far off when there will be built an Institute of Industrial Health on similar lines, for example, to the London School of Hygiene and Tropical Medicine; an institute for research, planned and co-ordinated, and closely linked with the various industries of the country; a centre of education and a bureau of information for all industrial health workers. But problems specific to different parts of the country, such as textiles in Manchester, light alloys in Birmingham, or ship-building in

[1] H.M.S.O. 1944. Pp. 313.
[2] *Canad. med. Ass. J.*, 1944, **50**, 63 (see p. 203).

Glasgow, must be studied by research workers who possess a practical working knowledge of the difficulties to be overcome. Here is the opportunity for the industrial medical officer to become part of the team and to initiate research. He knows his industry, and above all he knows his management and his workers. His co-operation with the Board and university departments, with facilities and trained workers for technical research, is essential to their success. Without his co-operation advances in knowledge will be retarded. It is to be regretted that much excellent work already done by certain Government departments will never see the light of day and so be applied to the common good. We thus suffer from living in watertight compartments.

It should be more generally realized by industry and government that research into medical and health problems is no less important than scientific research directly connected with economic production. The importance of the latter to the future wealth of this country is fully appreciated. Is it too much to hope that the health of those who specifically create that wealth will receive similar recognition?

HEALTH OF THE MINER

Industrial medicine includes within its scope industries other than those conducted in factories. And because there is a tendency to forget this, it is well to take a glance at the vast problem which confronts those responsible for the health of the coalminers. The figures for 1938 speak for themselves.[1] During the year some 6 million workers were employed in factories and something over three-quarters of a million in mines. Persons losing three days work or more from industrial diseases in factories numbered 3125, dermatitis accounting for 2420 of these; in mines men absent for the same time numbered 7767, nystagmus accounting for 1020 of these, and beat knee for 4505. Factory workers losing three days or more on account of injury numbered 218,317, including 718 fatal cases; 163,077 miners were similarly off work because of injury, with 983 deaths. In cash payments for compensation factory workers received £2,770,331 and miners £2,738,355 —practically the same amount. Here is one index of the problem and of the work to be done—both curative and preventive—in this developing branch of industrial medicine. The field is surveyed by Dr. S.W. Fisher elsewhere in this number of the JOURNAL. He makes the point that medical questions in the mine such as working environment, first-aid treatment, and a study of industrial diseases, must be tackled in their natural setting by observations in the place of work itself—down the mine. Uninformed criticism is never helpful and in many ways has done much harm to this vital British industry. But Fisher, who speaks with authority, does not attempt to deny that in mines there is much wrong to be put right; that accidents are all too frequent; that first-treatment facilities must be improved (for example by a nursing service organized at the pit head); and that we need increased knowledge of miners' diseases, such as pneumokoniosis and its relation to incapacity, beat hand and beat knee, and nystagmus. And then there is the question of working conditions—the effects of high temperature, humidity, lighting, dust and posture, and the urgent question of ventilation—all of which need further study.

The first medical inspector of mines was appointed in 1927. For many years he worked largely on his own. Only a few medical officers were employed by colliery owners, and, as in the case of factories, they were to be found mainly in the larger and more progressive organizations. Although other doctors have had much to do with miners—for example in examining them for compensation purposes, and in connexion with rehabilitation—their work has been done, for the most part, above ground. Far too few doctors have investigated conditions underground, at the place of work. Within recent months a new mines medical service has been set up, so far only on a regional basis and in skeleton form. It is a beginning, and it is interesting to note that it is a service organized and paid for by the State, where the doctor has an inspector's statutory right of entry into the mine. The larger employers will no doubt still continue with their own service, and their help and co-operation will be important in this new venture. But for the smaller mines, and for the less enlightened owners, a full service was never more urgently needed. Its post-war development will be watched with the greatest interest.

Meanwhile another medical provision for miners has developed with great rapidity. In January, 1943, the Miners' Welfare Commission accepted from the Ministry of Fuel and Power the responsibility of developing special rehabilitation services for the injured miners of Great Britain. Residential centres with facilities for gymnastics and for recreational and physical therapy have been established throughout the coal-fields in association with selected fracture A hospitals. In each area a full-time surgeon is appointed jointly to the fracture hospital and the rehabilitation centre; he is assisted by physical training instructors, masseuses, and occupational therapists; he is under an obligation not to engage in medico-legal litigation on behalf of the owner, the insurance company or the miner. Social problems and problems of re-employment and retraining are dealt with by a special member of the staff, closely collaborating with the management committee which is composed equally of miners and owners. Mr. Watson-Jones, who was appointed by the Commission as Honorary Director of Rehabilitation, recently reported progress[1] [2] and said that rehabilitation centres were now in operation for half a million miners; in

[1] Workmen's Compensation : Statistics of Compensation, etc., during the year 1938. Home Office, May, 1940. Cmd. 6203. H.M.S.O. Pp. 32. (No more recent figures are available as this issue has ceased for duration of hostilities.)

[1] *Iron and Coal Trades Review*, May 19, 1944.
[2] *Colliery Guardian*, May 19, 1944.

that respect no other industry in the country was so well served as the mines; experience was being gained by which the miners' rehabilitation service would be the forerunner of similar services for other industries in future years. The Chairman of the Miners' Welfare Commission, when opening yet another centre, forecast that by this summer the immediate requirements of practically the whole of the coal-mining industry would have been met by the provision of seven rehabilitation centres and six other centres at hospitals.[1] This is an outstanding achievement. Mr. Will Lawther, President of the Mine Workers' Federation of Great Britain, said on the same occasion that the provision of such centres brought a new hope and a new outlook to men in industry. It was true that in the past both sides had been satisfied with the payment of compensation to the injured, but to-day both realized that there was a common duty to see that 'life began again' for those injured in Britain's premier industry.

REHABILITATION TO COME

In 1941 the Ministry of Labour started a scheme[2] to help those who had been injured on active service, in air-raids, and in factories or elsewhere, to take up employment suited to their disability and to help those with pre-war disablement to prove their capacity for useful work, so that they could play their part in the war effort. A further pronouncement has now come from the Ministry,[3] consolidating the original scheme. That it is a forecast of things to come—and in particular of a widening of the meaning of rehabilitation—is indicated in the statement that 'the scheme provides, as an interim measure, facilities of the kind which will eventually be provided under the Disabled Persons (Employment) Act, 1944,'[4] recently added to the Statute Book. This Act will always be associated with the name of Tomlinson who piloted the Bill so successfully through the House of Commons. It is the direct outcome of the work of his committee which published its comprehensive report on rehabilitation in 1943.[5] The Minister of Production, Mr. Lyttelton, recently stated[6] that the Home Secretary would be presenting a new Workmen's Compensation Bill to the House.[1] This is of importance to those who are responsible for treatment and rehabilitation, because, again, it is a portent of things to come. Compensation laws are intricate; they have much to do with the economics of rehabilitation and for that reason need careful study. A new and inexpensive publication—price 3d.—provides for this in brief and simple form.[2]

This legislative activity is of special interest to the medical officer in industry, in particular the Disabled Persons (Employment) Act.[3] The movement to help the disabled man and woman of this country is another sign of the growing recognition of medicine as a social service: the Act itself has been described as 'a first instalment towards social security.'[4] But there is still a further implication, one which will materially affect the future of industrial medicine. Many men will be returning from the Services to industry who will be physically and mentally disabled. These men are to be fitted into our industrial structure. The State has set up the machinery for this, but it will fall to the doctor working within industry to set it in motion. He is the one man who knows both the detail of the work to be done and the capacity of the worker to do it: and it will be his personal challenge, when the time comes, to ensure that he is not only fully informed but fully prepared.

PAPER FOR THE JOURNAL

The first number of this JOURNAL was rapidly out of print, but a further allocation of paper enabled a second edition to be published. This has by no means met the increasing demand, and we regret that many individuals are unable to obtain their own copy. It has been suggested by a correspondent that copies of the JOURNAL could be circulated locally between groups of people who are desirious of seeing it. As many medical libraries as possible have been supplied with copies. These arrangements, however, are not satisfactory, and as soon as more paper becomes available more copies will be printed. In the meantime a waiting list is being kept of those who wish to have the JOURNAL, and they will be notified as soon as their wish can be met. Names will be taken in strict rotation.

[1] *Times*, May 23, 1944.
[2] Interim Scheme for the Training and Resettlement of Disabled Persons. Ministry of Labour, Oct., 1941. PL 93/1941. Pp. 8.
[3] Training and Resettlement of Disabled Persons. Ministry of Labour, March, 1944. PL 93/1944 (revised). Pp. 10.
[4] 7 & 8 Geo. 6. Ch. 10.
[5] Report of Inter-dept. Cttee. on Rehabilitation and Resettlement of Disabled Persons, Jan., 1943, Cmd. 6415. H.M.S.O. Pp. 51.
[6] *Times*, May 1, 1944.

[1] It has been reported that the White Paper embodying the Government's proposals for a new system of workmen's compensation will be published when Parliament re-assembles in September 1944.
[2] Memorandum on the Workmen's Compensation Acts, 1925–1943. Home Office, March, 1944. H.M.S.O. Pp. 18.
[3] This Act defines a disabled person as "a person who, on account of injury, disease, or congenital deformity, is substantially handicapped in obtaining or keeping employment, or in undertaking work on his own account, of a kind which apart from that injury, disease or deformity would be suited to his age, experience, and qualifications."
[4] *Times*, May 22, 1944.

REVIEWS

INDUSTRIAL MEDICINE

Edited by Sir Humphrey Rolleston, G.C.V.O., K.C.B., M.D., F.R.C.P., and Alan Moncrieff, M.D., F.R.C.P.

(Eyre and Spottiswoode, Ltd., London. 1944. Pp. 202, 16*s*.)

Every practitioner working in an industrial area, even if he has no official position, is faced with problems of industrial medicine, and it is particularly for such that this book has been prepared. It is not a detailed treatise on the subject, nor does it fully achieve its object of surveying the field—largely because of lack of editorial balance. There are eighteen monographs by different authors. Sir David Munro wisely points out at the beginning that industrial medicine covers the whole field of medicine and surgery, and the proper placing and environmental supervision of a man with peptic ulcer is a much more common problem to the works medical officer than a toxicological one. In fact all the ordinary diseases may happen to workers and are the same diseases whether they occur in hospital, in the factory, or in the home. H. M. Vernon surveys the field of toxicology. He gives a brief review of the toxic action of lead, arsenic, mercury, trinitrotoluene, carbon monoxide, pitch and tar, and chrome. For some obscure reason anthrax is included in this chapter: this is certainly a bacterial disease and not an industrial poison. Dermatitis is a difficult problem in industrial medicine at the present time, and it is well reviewed by A. D. K. Peters. A. J. Amor gives an account of the many chest diseases which may arise in industry. He stresses the anatomical approach to the problem and the point in the bronchial tree most likely to be affected by noxious substances. Besides those dusts which harm the lung, many toxic substances such as lead and benzene gain access through it, and the escape of any toxic materials into the air of the workroom should be prevented by all possible safety measures. Ethel Browning writes on toxic anaemia. Under factory regulations (1942), toxic anaemia is recognized as a notifiable occupational disease and this has great informative value for the factory inspectorate. It covers every sort of anaemia from chronic benzene poisoning to anaemia in an x-ray worker examining metal castings. She gives typical blood counts on workers exposed to benzene with 'slight' 'moderately severe' and 'severe' exposure, but this is of little value without a statement of the actual concentration of benzene in the atmosphere. William Gissane from his wealth of experience in the Birmingham Accident Hospital describes the treatment of the injured workman. He does not give technical details of the surgical procedures necessary for the proper management of the various types of injury, but these would be out of place in this volume. Nutrition is discussed by H. A. Krebs, and the important environmental subjects are dealt with: lighting by E. W. Murray, ventilation and heating by T. Bedford, fatigue and boredom by May Smith, welfare services by Robert Hyde, and the works ambulance room by P. Pringle. Other subjects include miner's nystagmus, backstrain, neuroses, malingering, and adolescents in industry. The book finishes with an able account of factory law in relation to health and welfare by A. I. G. McLaughlin. This chapter is well produced and is likely to be of great value to all who have dealings with factories and factory workers.

It is opportune that this book should be produced at the present time when such a large proportion of the population is engaged in manufacturing the essential weapons of war. It is not merely a war-time problem, for it is made clear by several of the contributors that when a factory management has once employed a medical officer and set up a medical department, it is most unlikely to discontinue what it finds to be a great asset to the happiness and efficiency of the workers. This book has been compiled for the general practitioner and medical student, and can be recommended for them. It is not intended for industrial medical officers.

K. M. A. P.

INDUSTRIAL TOXICOLOGY

By Donald Hunter, M.D., F.R.C.P.

(Clarendon Press, Oxford. 1944. Pp. 80. 10*s*.)

This is a detailed review with bibliography and index of the effects of toxic substances encountered in industry. It is sub-divided into four sections as follows: the metals —lead, arsenic, mercury. The aromatic compounds: aromatic *nitro* and *amino* derivatives; tri-*ortho*-cresyl phosphate. The chlorinated hydro-carbons—methyl chloride, carbon tetrachloride, ethylene dichloride, tetrachlorethane, trichlorethylene, chlorinated naphthalene. The glycol group—ethylene chlorhydrin, diethylene dioxide.

It is the Croonian lectures of the Royal College of Physicians for 1942, and is reproduced from the *Quarterly Journal of Medicine*, 1943, **12**, 185. The author starts by giving a brief account of the various toxic symptoms associated with the metals, and then goes on to give a very full description of the toxicology of lead with all the most modern developments in this field. He stresses the difference between the symptoms of ordinary lead poisoning and the encephalopathy arising from the absorption of tetra-ethyl lead through the unbroken skin. This is followed by arsenic and mercury; neither has been worked out as exactly as lead and therefore do not have the same wealth of literature. The recent work of the Boston group of investigators headed by F. T. Hunter on the toxicology of benzene is fully stressed; they pointed out that rather than depression of the white cells being the early manifestation, leucocytosis is a commoner manifestation and leukaemia may even develop. Little work has been done on the aromatic *amino* and *nitro* derivatives during the present war, and it is a pity therefore that the Ministry of Supply will not allow the work of Witts and Stewart to be published. Tri-cresyl phosphate is an important plasticiser and though its symptomatology is known from the epidemic caused by *Jamaica ginger* in the United States, the first account is given of cases having arisen in industry in this country. The chlorinated hydrocarbons are mostly toxic substances. Since this book was published Hollings has reported poisoning similar to that from methyl chloride arising from methyl bromide used as a fire extinguisher in the Navy. A full account is given of methyl chloride toxicology as of the others of this group. Again, since the publication, Hunter himself has suggested that the trigeminal anaesthesia long associated with trichlorethylene is really caused by its decomposition substance dichloracetylene. The last section deals with the glycol group. A great new aliphatic chemical industry has grown up around these substances which is already bigger than the coal tar or aromatic industry. The two principal substances whose toxicology is described are ethylene chlorhydrin and diethylene dioxide.

The review finishes with a very extensive bibliography, and it will be found an indispensable reference book to all who have a potential toxicological hazard in industry.

K. M. A. P.

INDUSTRIAL NURSING: ITS AIMS AND PRACTICE

By A. B. Dowson-Weisskopf, S.R.N.

(Edward Arnold & Co., London. 1944. Pp. vii+159. 5*s*.)

In the rush and bustle of war new functions have frequently been fastened on to many categories of people without adequate time being given to precise definition of scope. In this country reliance is always placed upon empirical methods: we learn by experience and are suspicious of all-embracing definitions particularly in matters relating to human beings. However excellent may be the ultimate outcome of this approach, there is bound to be much muddle in the process of settling in and getting everybody to understand what has happened.

In the field of industrial hygiene, health, and welfare there has been just such a process of muddle. Orders were issued by the Ministry of Labour that medical supervision must be introduced and it was left in large measure to industry to discover what medical supervision of workers meant. Certain it is that the great majority of doctors and nurses who were thus pitchforked into industry did not know what it meant and thus different interpretations emerged. Some of these interpretations, as manifested in actual practice, were frankly reprehensible, both in the manner in which some employers defined the work's doctor's functions and in the manner in which some doctors applied their art to industry. Members of the nursing profession were appointed into industry to provide health supervision or care of workers and were in many cases grossly exploited. Regularization of the position was made possible by the efforts of the British Medical Association and the Royal College of Nursing. These bodies made valiant attempts to define the scope of medical and nursing services in industry, to lay down ethical rules, scales of salaries, and to support or organize training courses for persons proposing to enter or actually in these services.

The path to the full regularization of these services is uphill, for whereas the employer has some reason to consider the doctor or nurse appointed by him as subject to his jurisdiction, the work-people have a natural tendency to suspect a service which, whilst claiming to be established in their interests, has many aspects suggestive of an interested paternalism in which the doctors and nurses have the appearance of employer's men and women. There will be much heart-burning before a solution, satisfactory both to employers and workers, is found, particularly for the hosts of small concerns.

In the little volume under review, the author takes up something of a fighting position. To her the nurse in industry, considered mainly as working on her own without the direction of a medical officer, is an independent person and can exercise her authority in an enormous field; and should she be dissatisfied with any aspect of her work it is her right to beard the chairman, the managing director, or anybody else, in his den and demand satisfaction. The author goes further in saying that the nurse should discuss with the Factory Inspector the desirable changes in the factory; and even further, in stating that the nurse should demand the dismissal of officials who, in her view, are having an adverse effect upon the workers' health or welfare. The state of mind of the author is illustrated by the following: 'Since industrial managements are lay bodies concerned with production and except in war-time, with marketing their goods, who may know very little about health services, it is unwise that they should entirely prescribe the limits of the nurse's work.' These limits must presumably be laid down by the nurse or by the nurse's organizations, and, says the author, it must be demonstrated to the employer by results that it pays. This is a pernicious doctrine. There is only a single criterion of the value of health and welfare service in a factory: it is that the service ministers, within its province, to the needs, physical and psychological, of the workers. That such services pay or do not pay is irrelevant and not the concern of nurses or doctors.

It is interesting that the author, in giving an example of what an annual report by the nurse should comprise, starts the report with a section headed 'Workmen's Compensation,' in which actual figures of money paid are detailed. Is it intended that corresponding to the 'Compo Doctor' there shall now be a 'Compo Nurse'? Except to report on the purely medical aspects of injury or disease, as she sees them, the nurse in industry should have nothing whatever to do with matters in which a financial transaction arises between a worker and an employer. We must confess to a certain apprehension when we hear the views of certain leaders of the nursing profession which seem to favour the development of a nurse in industry with many of the characters of business personnel. Is it too Victorian to prefer the older conception of a nurse as a person dedicated to the service of mankind—with the proviso that it shall be the business of the State to prevent exploitation—and not involved at all in the selfish scramble of commerce? It is suggested that a nurse of this kind obtains the co-operative and understanding response from employers and professional managers, coupled with respectful deference and even homage, which are never obtained by the business-woman type.

We would recommend the perusal of this little book rather as an index of topics calling for study by the industrial nurse than as a reliable text-book for practice. For the latter the nurse in the factory will have to look elsewhere.

M. W. G.

ABSENCE FROM WORK: PREVENTION OF FATIGUE

Industrial Health Research Board Pamphlet No. 2

(H.M. Stationery Office. 1944. Pp. 20. 3*d*.)

It is not an easy matter to describe the results of scientific research in simple language, or in terms that can be understood by 10 million workers in industry. Investigation into the varied problems of absenteeism and of fatigue involve technical details and descriptions which have been presented from time to time in reports from the Board. It has undoubtedly taken courage, therefore, for a research body to depart from precedent by simplifying language and to enter the field of education. But results fully justify the decision. This pamphlet, even more so than its predecessor on ventilation and lighting, is a brilliant example of what can and must be done to make the findings of scientific research understandable to everybody. For 3*d*. we have a gold-mine of information. Attractive illustrations add to its interest. But its motif is dead serious and the facts it presents are an indictment of our industrial machine. During this war absentee rates of 6–8 per cent. for men, and 10–15 per cent. for women are generally found. While some reasons for this may be outside the control of the individual worker, the lead in prevention must be taken by the group of people most directly concerned—the men and women on the job of production, and this includes the highest management. 'Weekly hours of work should not exceed 60 for men and 55 for women . . . for heavy manual workers and women with home duties these hours are still too long . . . a week-end break is important . . . weekly hours should wherever possible be spaced over a five-day week . . . in severe muscular work a break of 5 or 10 minutes every hour is better than a single break of 15 minutes in the middle of a spell . . . it is often possible to adjust the machine, the seating, or arrangements of work so as to avoid excessive strain and waste of energy.' These are strong words; and they hit hard at many employers.

Although the pamphlet already sells by the thousand, it must sell by the tens of thousands and more. Those of us who work in industry—doctors, nurses, welfare workers, managers, and shop stewards—must act as selling agents. For example it would be good to see it on railway station bookstalls. Facts are given to us in straight downright talk; the remedy is suggested; it is for the people of this country to decide what will be done.

D. S.

HEALTH EDUCATION ON THE INDUSTRIAL FRONT

(Humphrey Milford, Oxford. 1943. Pp. 63. 8*s.* 6*d.*)

This stimulating little book contains five lectures given to the 1942 health education conference of the New York Academy of Medicine. The first by Cassius H. Watson discusses in general terms all the problems involved in the 'industralization' of the community in wartime, and this acts as an introduction to a more detailed discussion of the various aspects in the later lectures. Otto A. Bessey describes the arrangements necessary for adequate nutrition for the population. He implies that the industrial canteen has been more developed in this country than in the United States; and stresses that its importance is to make certain that the people get the right foods to maintain health and strength and not necessarily the ones they like most. Leonard Greenburg defines the work of the industrial medical officer. 'Our purpose is to control plant working conditions so that an optimum environment may be provided for the worker; an environment in which he can work with safety and under conditions which are not detrimental to his health. This portion of the problem may and usually is given the name of industrial hygiene, and includes such phases as plant sanitation, illumination, ventilation, safety provisions, occupational disease control, and many others. The second portion of the problem is essentially non-occupational and consists in the conservation of the health of the worker through general supervision, and by the prevention of physical defects, their early detection and correction. Finally, the third phase consists in the restoration of the worker to health and earning capacity as promptly as possible following accident or disease.'

In considering mental problems and morale Łydia G. Guberson stresses that the doctor must be a good listener with considerable patience; and it will help him tremendously if he has a sincere interest in human beings and their almost innumerable difficulties. Lastly, Harold R. Baxter records that more Americans will die this year because of civilian accidents than were killed by the Germans in the first World War: the education of workers in the control of accidents in industry is therefore of the greatest importance.

To those who think about the purpose and development of industrial medicine, this book will give many ideas. K. M. A. P.

INTERIM REPORT OF THE SOCIAL AND PREVENTIVE MEDICINE COMMITTEE OF THE ROYAL COLLEGE OF PHYSICIANS

(R.C.P. London. 1943. Pp. 32.)

This excellent interim report makes the following recommendations:

(i) That every medical school should establish a Department of Social and Preventive Medicine, the size and scope of the department depending upon the facilities and personnel available.

(ii) That this department should organize a modernized course in Social and Preventive Medicine to replace the present course in Public Health, which, as in the clinical subjects, should be a curriculum founded securely on the basic sciences, growing and expanding through the three clinical years.

(iii) That as well as theoretical teaching such a curriculum should bring the student into close touch with the active organizations in the community concerned, particularly with social and preventive medicine—namely, the health services provided by the local authorities, and the almoner's department within the hospital.

(iv) That all medical schools should recognize the importance of problems associated with industrial medicine.

(v) That student health services should be available in every medical school and that under the general direction of the head of the department of social and preventive medicine they should be used as an instrument of teaching.

(vi) That all teaching hospitals should employ properly trained almoners and psychiatric social workers, both in the care of patients and in the teaching of students.

(vii) That the Royal College of Physicians should take an active interest in the organization of the teaching of social and preventive medicine, not only to medical students, but also to nurses and medical social workers.

To-day the average doctor has little or no idea what conditions are likely in a factory, and therefore he is not capable of deciding if a man's job has any relation to the symptoms he complains of, and if so what action should be taken. It is not surprising therefore that complaints come from many industries about incompetent medical certification. This is not the fault of the doctor since he is never taken into a factory as a student and taught how a large part of the population spend the greater part of their days. We therefore welcome the statement by this committee that the medical student is not expected to become an expert in occupational diseases. It is much more important that he should acquire knowledge and understanding of the social problems relating to industry and be able to recognize the mental and physical response of his patient to fatigue, overwork, monotony, unsuitable hours or type of employment. For this purpose, the practical course in preventive medicine should bring him into personal contact with industrial conditions through visits to factories, and demonstrations of both good and adverse conditions, the latter in industrial museums where such exist. From experience in visiting industrial concerns, it is evident that teaching visits would be greatly welcomed, both by the management and the workers. Surprise is expressed that such visits have not taken place before; and they would certainly result in industry placing much greater trust and reliance in the medical profession.

Not only is the environmental side of this report important, but it shows that preventive medicine can be practised extensively in the factory. The value of mass miniature radiography is already established. By this means the unsuspected case of pulmonary tuberculosis can be found and treated, and at the same time be removed from contact with healthy individuals who are thus protected from the most deadly single disease which attacks people at the prime of their working life. The importance of rehabilitation is also recognized. It is to be hoped that experiments such as the 'sheltered shop' in which the hospital officer visits the shop and cooperates with the engineer in restoring an injured man to work will be greatly extended. It is important that medical students also see the patient here, as well as in the clinic and hospital. We must learn to understand the full implications of treatment, after-care and restoration to employment. K. M. A. P.

ABSTRACTS

Postgraduate Education in Industrial Health and Hygiene. SOLANDT, D. Y. *Canad. med. Ass. J.*, 1944, **50**, 63.

In Canada the industrial hygienist has found scope for his activities chiefly in provincial and Federal Government organizations. In the future it is certain that the larger industries will employ full-time hygienists as part of an industrial health programme. With this movement has come the general desire that full-time and part-time physicians in industry shall become conversant with the field of industrial hygiene. Short courses in industrial hygiene have been offered by McGill and Toronto Universities, and the response from the profession indicates that this type of tuition is considered to be of real value. Long courses have been given as adjuncts to courses in public health, but the diploma or degree granted gives no indication of the specialization.

In setting up a course in industrial hygiene in the Faculty of Medicine, University of Toronto, it was thought inadvisable to increase the time spent in industrial work at the expense of other subjects in the D.P.H. course. For this reason a Diploma in Industrial Hygiene (D.I.H.) was created. The diploma course occupies one academic year (eight months' didactic and laboratory work and three months' field work) and is open to any graduate of an approved medical school. Graduates holding an acceptable post-graduate qualification in public health may make application for exemption from the latter half (four months) of the didactic and laboratory work. Fieldwork credit is given for industrial experience gained prior to taking the course. It is hoped that in the future a course may be open to university graduates not holding a medical degree.

The subjects covered in the complete course are bacteriology and immunology, epidemiology and biometrics, physiological and industrial hygiene, nutrition, toxicology, public health chemistry, public health administration and education, sanitation and pertinent material in the fields of medicine and surgery. *The Diploma in Industrial Hygiene thus offered by the University of Toronto is, so far as is known, the only specific recognition of postgraduate work in the field of industrial hygiene or industrial health which has ever been or is at present available to those requiring special instruction in this field.*

Short courses are invaluable where time cannot be spared for more complete training. The long course described and being offered at the University of Toronto represents a serious attempt to aid the Canadian medical profession in its task of supplying trained men to industry and to Government bodies responsible for advising industry in matters pertaining to health. It is hoped that immediate beneficial results may ensue, although the press of activity in a nation at war will certainly limit the extent of such an educational programme. Full development in the field of industrial health and hygiene will probably not be attained until the period of social expansion which will inevitably follow the peace. Steps towards this goal are fortunately compatible both with a vigorous pursuit of the war-effort and with intelligent planning for a post-war world. R. S. F. S.

A Social Medicine Based on Social Statistics. FLORENCE, P. SARGANT. *Nature*, 1944, **153**, p. 363.

The study of industrial fatigue, defined broadly as a study of the variations in human health and efficiency associated with variations in industrial conditions, is unquestionably a special branch of social medicine. In the field of social biology there must be investigation of industrial factors such as training of workers, selection methods, and conditions such as hours worked. Results will vary with the persons or group of persons upon which the impact of the purely environmental condition falls. A study of 'type'—sex, age, heredity, education, experience—therefore comes within this field.

Examples of recent research in social medicine include reports by the Industrial Research Board on measurements of height, weight, and muscular strength of unemployed, the relation of type of work to sickness absence, and accident proneness in factories. D. S.

Venereal Disease Education in Industry. RHODES, H. CECIL, and CLEVELAND, E. H. *Canad. publ. Hlth. J.*, 1943, **34**, 11.

This article describes an 'Industrial Health Education Week' from 15th to 20 February, 1943, in Columbia, financed by the Provincial Board of Health and having as its object 'making essential factual information about venereal disease and its control available to employed workers and their families, on as wide a scale as possible . . . to arouse support for measures designed to combat the disease.' An intensive education programme, directed to members within the organizations concerned with launching the main campaign, was a preliminary. Personal support was publicized from the Premier, Mayors, Church dignitaries, Union officials, parent-teacher associations, Boards of Trade and military leaders. General publicity and support came through the press, radio, billboards, theatre trailers, street car cards, and window displays. 'The focal point of the campaign was the distribution of literature'—and this appears to have been on a most ambitious scale.

Results of such a campaign are very difficult to assess. Further details of the technique employed are available on application to the Division of Venereal Disease Control, Provincial Board of Health, 2700, Laurel Street, Vancouver, B.C. T. O. G.

A Study of Pneumonia in the Shipbuilding Industry. The Epidemiology and Management of 864 Cases over a One-Year Period in the Kaiser Richmond Shipyards. COLLEN, MORRIS F., DYBDAHL, GERHARDT L., and O'BRIEN, GEORGE F. *Journ. industr. Hyg.*, 1944, **26**, 1.

In the twelve-month period from Sept., 1942, to Sept., 1943, 864 patients were treated at the hospital which furnishes medical care to the 90,000 employees at four shipyards. The annual frequency rate of pneumonia was 9·5 per 1000 workers, and the gross mortality rate of the patients treated was 8·2 per cent. The incidence of pneumonia did not appear to differ from that observed among the general population, and the rate appeared to be independent of the type of work done in the shipyards. Pneumococcal pneumonia accounted for over 70 per cent. of the cases, with types VII, I, and XXV making up a third of all typed pneumonias. The value of a low leucocyte count as a measure of the severity of pneumococcal pneumonia was indicated, for the 21 per cent. of the patients with a leucocyte count of 10,000 or less had a mortality of 27 per cent., whilst the remainder, with higher leucocyte counts, had one of only 4 per cent. H. M. V.

Diabetes and Injury. BISHOP, WILLIAM A. *Journ. industr. Hyg.*, 1944, **26**, 55.

The author's opinions are based on experiences with diabetic cases lasting over a period of twenty years. He believes that diabetics can be employed in industry provided certain safeguards are adopted, but uncontrolled diabetics are a menace to themselves and others. Some moderate, and all severe diabetics, should avoid heavy types of labour, hazardous jobs, and elevated positions. As regards the question of diabetes being aggravated by trauma, the author points out that if a diabetic, who has his disease under control, is rendered completely inactive by an injury such as a fractured leg, a considerable part of his sugar-burning mechanism is put out of action. Unless the diet is modified there will be more sugar in the urine and blood, and the diabetes may get out of control. In cases of thyroid disease, an injury may increase the severity of the diabetes owing to the increase of metabolism by the hyperthyroid state. The author considers that infections bear no causal relationship to diabetes, but they are potent factors in making an existing diabetes worse. The sulphonamide drugs have no deleterious effect on diabetes, and are as potent in the control of infection as in non-diabetics. Inhalation anaesthesia may be followed by glycosuria, but there is no good evidence that it causes diabetes or makes an existing diabetes worse. H. M. V.

Effect of Wet Garments on Body Weight Loss at High Environmental Temperatures. LIFSON, NATHAN, and VISSCHER, M. B. *Journ. industr. Hyg.*, 1943, **25**, 434.

The practice of wearing wet clothing by workmen in hot situations such as furnace rooms has been employed for a long time. In order to investigate the limiting environmental conditions under which this procedure is effective, eleven subjects, aged 18 to 25, were employed. They usually wore long-sleeved, long-legged underwear which, when wetted, took up 1250 g. of water. The subjects either rested, sitting down, or worked by stepping up and down 17–18 times a minute on a box 5½ inches high. Experimental periods lasted 55–90 minutes. At a temperature of 110° F., relative humidity up to 25 per cent., and wind velocity of 25 ft. per minute, the average rate of weight loss at rest with wet underwear was 64 g. per hour as compared with 238 g. in the nude, yielding a saving of 174 g. attributable to the wet garment. When at work, the corresponding values were 279 g. with wet underwear and 588 g. in the nude, or an hourly saving of 309 g. The pulse rate of the resting subjects was 11 beats per minute less with wet underwear than with none, and 7 beats per minute less when at work. When the humidity of the air was 35 per cent. or more these advantageous effects were absent. Other somewhat similar tests are described, and it is suggested that further investigations should be made for application to specific situations. H. M. V.

Toxic Anaemia. BROWNING, ETHEL. *J. industr. Hyg.*, 1943, **25**, 124.

Toxic anaemia was made a notifiable disease in the early part of 1942 so that the Factory Department could obtain all the information possible on the effects on the haematopoietic system of the variety of chemical substances now being increasingly used in industry. In industrial medical practice it can be regarded as a dyshaematopoietic anaemia rising in an individual who has been exposed to some substance known to exert, or suspected of exerting, an injurious effect on blood-forming organs.

Examples of haematological examinations of workers exposed to known and suspected toxic agents are given. The blood picture of benzol poisoning reported by early workers was a leucopenia. Lately more attention has been focussed on the significance of a relative lymphocytosis unaccompanied by leucopenia. Examples of the latter are shown in a group of works mixing and spreading a paint containing 40 per cent. benzol.

The toxic effects of carbon tetrachloride on the liver and kidneys are well known. Nevertheless a fatal case is recorded in which, following exposure to this solvent, blood counts during life gave a picture of anaemia, leucopenia and relative lymphocytosis. At necropsy, the liver showed only an increased number of cells in the portal tract, some siderosis, and an excess of Küpfer cells, while the kidneys were normal.

Similarly a fatal case of aplastic anaemia and a severe case of hypoplastic anaemia are recorded in two workers exposed to trichlorethylene, which has never been regarded as having any special affinity for the blood-forming organs.

Other solvents discussed are xylol, solvent naphtha, and mixed solvents and thinners, which latter are used in cellulose paint spraying.

Blood changes have also been observed in industrial workers exposed to radio-active luminous compounds. Few significant variations in the red cell count and haemoglobin percentage have been found. In a certain number of operatives a fall in the total white cell count to 4300–4900 per cu. mm. has occurred. On removal from exposure, the white blood count has usually returned to a more normal figure. The most constant finding has been a reversal of the normal leucocyte/lymphocyte ratio. Another interesting phenomenon has been the appearance in stained films of a large white cell resembling a transitional lymphocyte with a large horseshoe-shaped nucleus. R. S. F. S.

Toxic Effects in Women Exposed to Industrial Rubber Solutions. HAMILTON-PATERSON, J. L., and BROWNING, ETHEL. *Brit. med. J.*, 1944, **1**, 349.

The clinical and haematological pictures of 200 women working with industrial rubber solutions * are compared with 200 controlled women with a view to determining the toxic effects. Neutropenia is shown to be the commonest and earliest sign of benzene absorption.

The examinations were carried out in thirteen factories scattered over the country, and the investigation was conducted in two parts. In the first, sample groups were clinically examined and had blood counts done. These counts were compared with the counts of a similar number of control women. In the second part, all the women working in one factory were similarly compared with a group of women in the same factory who had never been in contact with rubber solution. The effects of 'rest' were also studied in this group of women. Even although adequate ventilation is provided, as required under the India-rubber Regulations, 1922 (S. R. & O., No. 329), it is almost impossible for some workers not to inhale the fumes and to be exposed to a high concentration of benzene. Where treated articles remain in the workroom there may be a further increase of benzene in the atmosphere. The general atmospheric concentration of benzene is not an entirely reliable criterion of benzene exposure, since individual workers may at any time be exposed to localized 'pockets' of high concentration, particularly when working over open containers.

It is noted that the substitution of a relatively non-toxic solvent such as solvent naphtha would render blood control of the worker unnecessary, but as long as benzene is used it is advisable that workers should be given the protection of routine blood examinations.

The excretion of increased amounts of organic sulphates in the urine is a feature of severe benzene poisoning, but in this investigation no definite changes were found in workers who by clinical and blood examination showed definite and early signs of disease. It would therefore seem that benzene can produce blood changes before it is excreted in significant amounts.

* Rubber solutions contain varying amounts of benzene and of the aromatic hydrocarbons benzene, xylene, and toluene; xylene and toluene are less toxic than benzene, but the latter is still used because of the difficulty of obtaining the former in sufficient amounts. As the result of representations by the Factory Department the aromatic content of the rubber solutions used in the special manufacturing process (aircraft industry) investigated was limited to 5 per cent.

It was also shown that there is no correlation between symptoms complained of and the onset of blood changes. This is important because clinical examination alone is probably useless for the specific detection of early cases.
D. S.

Skin Absorption of Tri-*ortho*-cresyl Phosphate as shown by Radio-active Phosphorus. HODGE, H. C., and STERNER, J. H. *J. Pharm. exper. Therap.*, 1943, **79**, 225.

An attempt was made to estimate the amount of tri-*ortho*-cresyl phosphate that can be absorbed through unbroken skin, and how rapidly the absorption occurs. Tri-*ortho*-cresyl phosphate containing radio-active phosphorus was used and the absorption measured in two human subjects and one dog. The human subjects applied 0·22 g. and 0·11 g. of the tri-*ortho*-cresyl phosphate with radio-activity of 395,000 counts/mm./0·1 g. The first had thirteen micrograms of tri-*ortho*-cresyl phosphate per 100 c.c. of blood at the end of one hour, and he excreted seven micrograms in the urine in the first hour, and continued at 35 micrograms an hour for the next 24 hours. He excreted 797 micrograms or 0·36 per cent. of the amount applied. The second had four micrograms per 100 c.c. of blood at the end of one hour, and excreted 143 micrograms or 0·13 per cent. of the amount applied.

2·094 g. of tri-*ortho*-cresyl phosphate was applied to the abdomen of a bitch and the blood level quickly established itself at 8 micrograms/100 c.c. and maintained this for 24 hours. The urinary excretion began equally promptly, being 44 micrograms in the first hour rising after seven hours to a maximum of 1312 micrograms. The tri-*ortho*-cresyl phosphate was distributed in the various tissues of the dog 24 hours after its application to the abdominal surface. The retentions were in the following order: visceral organs, muscle, brain, bone.

The authors consider that the magnitude of absorption of tri-*ortho*-cresyl phosphate through human skin is such that a real hazard exists in industrial operations permitting a considerable or repeated exposure to this compound. A safe industrial hygiene control requires that measures be taken to prevent such skin contact, and that all workmen exposed to the compound be instructed as to the hazard, and the necessity for preventing skin contamination.
K. M. A. P.

Toxicity of Lead Chromate. HARROLD, G. C., MEEK, S. F., COLLINS, G. R., and MARKELL, T. F. *Journ. industr. Hyg.*, 1944, **26**, 47.

A number of investigators have noted that some lead compounds are less toxic than others, but most of the observations have been made on lower animals. The present investigation relates to the toxicity of one compound, lead chromate. The paints used as spray materials contained less than 1 per cent. of the lead in the form of lead oxide. Risks of poisoning the subjects under observation were reduced by improvements in the exhaust systems of the spray booths and other engineering changes, and by personal protective devices. Lead in the air samples was determined by different methods, and comparisons of the results are recorded. At the same time samples of the blood and urine of the subjects were collected. Previous investigations with lead oxide showed that there was a positive correlation between the lead in air, the urinary lead and the basophilic aggregation, whereby the degree of exposure to lead absorption could be reduced. In the present investigation the basophilic aggregation and lead in urine correlated, as before, but they did not correlate with the atmospheric lead concentrations. Observations were made on one group of 145 men and another of 40 men, the tests being made monthly for 16 months. The actual lead inhaled was 12 to 18 mg. per day, but subsequently—over a 12-month period—the lead exposure was less. The basophilic aggregation and urinary lead were not significantly greater than in normal persons unexposed to lead except for the small amounts usually ingested in food. It seems probable that other insoluble lead compounds may resemble the non-absorptive properties of lead chromate.
H. M. V.

Lead Exposures at the Government Printing Office. BRANDT, ALLEN D., and REICHENBACH, GEORGE S. *Journ. industr. Hyg.*, 1943, **25**, 445.

The Government Printing Office is the largest single industry of its kind in the United States of America, and it was deemed advisable to check the atmospheric concentration of lead in those rooms where lead is being processed or handled in quantity, in order to ascertain whether the existing control measures are adequate. More than 100 samples of air were collected on 14 days by means of a standard all-glass impinger and the electrostatic precipitator. The various rooms were provided with mechanical ventilation, there being about 35 air changes per hour in the remelt room, and 15 changes per hour in the monotype department and other rooms. It is considered that the maximum allowable lead concentration is 0·15 mg. per cubic metre, and observations showed that the average weighted exposure for all workers in the departments studied was below this maximum. However, operations in the monotype casting, stereotype and remelt departments presented potential exposures high enough to justify periodic physical examination of the workers in order to detect early symptoms of abnormal lead absorption. The highest individual lead values observed were, 0·59 mg. in the monotype room, 0·44 mg. in the stereotype room, 0·44 mg. in the routing operation and 0·30 in the shaving operation.
H. M. V.

Disabled Ex-Service Men in the U.S.S.R. *Soviet Medical Chronicle*,* March, 1944.

To ensure efficient medical after-care for men invalided out of the armed forces the Commissariat of Public Health has allocated some of the leading hospitals and specialists specifically for this work. Units in plastic surgery, psychiatry, ophthalmology and other specialisms have been selected at central research institutes. While in hospital the men receive not only medical treatment but are also trained for an occupation. For example 3796 men have learned new trades in hospitals in the Novosibirsk region during the war. In one hospital alone 99 book-keepers and accountants, 31 cinema technicians, 18 drivers, 16 bee-keepers, 31 shoe-makers and 9 cooks were trained. At vocational residential training homes, where disabled men are fully maintained by the State, men have been trained as shoe-makers, tailors, watch-makers and photographers.

The rehabilitation of ex-servicemen, their placement in suitable work, and the maintenance and improvement of their economic conditions are the care not only of those who administer the social insurance funds but also of public organizations and of the local Soviets. The great majority of men who have been invalided out of the Services are already back at work in factories, institutions, and collective farms, at their former work or in new occupations, according to their degree of disability.

In order to improve the co-ordination of plans for the industrial rehabilitation of disabled ex-servicemen, the Council of People's Commissars has issued a new regulation with regard to the work of the industrial medical committees. The committees will consist of specialists from hospitals and polyclinics, doctors from factories, and representatives of the Trade Unions. The duties of the committees are three-fold: to ensure that medical care and attention are readily available, if needed; to study the suitability of different occupations for these men; and to advise with regard to their placement in industry and to ensure that, having been placed, they receive any assistance that may be necessary.
D. S.

* Published by the Anglo-Soviet Medical Council, c/o The Royal Society of Medicine, Wimpole Street, W.1.

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TOXIC EFFECTS OF ETHYLENE CHLOROHYDRIN

Part I.—CLINICAL

BY

M. W. GOLDBLATT and W. E. CHIESMAN

Manchester

Literature

In spite of the toxic properties of ethylene chlorohydrin,* there is only one paper, so far as we know, which deals at all adequately with this compound. This is by Koelsch (1927) who refers to nine cases of which two were fatal ; he also gives results of animal experiments. The circumstances in which these cases occurred are probably unlikely to be repeated—three cases (one fatal) during the use of the compound as a machine cleanser, and four others (one fatal) during its use as a solvent in a quick drying stain for oil-cloth.

The first victim, a man of 30 years, had been cleaning a machine with ethylene chlorohydrin and was exposed to a high concentration of vapour on a summer's day for some 2½ hours, and there must have been considerable contact with the skin for the job was done with a rag soaked in the cleansing agent. The symptoms which followed were nausea and vomiting, violent headache, and giddiness. The medical attendant noted no fever; cardiac action was normal; there were isolated pulmonary râles. Later in the day there was repeated bilious vomiting, followed by great thirst. Next morning the patient rose, drank some coffee, became unconscious and died shortly afterwards. Autopsy showed numerous ecchymoses, inflammatory detachment of large parts of the mucous membrane (and small isolated ulcers) in the respiratory passages, and pulmonitis mainly in the right lung; there was evidence of old pulmonary tuberculosis and valvular disease of the heart; the gut was normal, but the liver was considerably enlarged; the kidneys appeared normal.

Of the other two men engaged on the same cleaning operation, but under much less exposure, one complained of nausea, vomiting, violent pre-cordial pain, giddiness, and weakness, but was quite well on the following day ; whilst the second complained only of slight burning sensation in the eyes.

The second fatal case described by Koelsch was one of four men engaged in staining oil-cloth with colour dissolved in or mixed with ethylene chlorohydrin. Exposure must have been considerable and the man developed nausea and signs of narcosis and had to stop work early in the day; the doctor held the condition to be of little moment, but in the afternoon dyspnoea set in and the man died in the evening. Autopsy showed cerebral and pulmonary oedema, acute gastro-intestinal catarrh, renal degeneration and disease of the cardiac valves and aorta as well as calcification of the arteries. The last of these findings was held (not by Koelsch, who merely quotes) to have been brought about by an acute poisoning. The remaining three men were relatively mildly affected, and although two required long treatment and convalescence, no permanent sequelae resulted.

Koelsch also refers to two other cases which had been reported to him, but although they had been severely ill, complete recovery occurred in both.

Reference must be made to the short note by Middleton (1930) on a fatal case of a lead burner. Two men were engaged in the repair of a leak in the lead lining of a still, which contained ethylene chlorohydrin. The men both had considerable direct skin contact with the water-chlorohydrin mixture which had to be removed before the leak could be repaired. When the chlorohydrin had been cleared, as far as could be judged by odour, the lead burner spent about 1½ hours repairing the leak with an oxy-hydrogen flame. His mate, who had done most of the mopping out of the still and hence had most of the skin contact, leaning over the manhole to give necessary assistance in the repair, experienced nausea. Both men, after the job was done, suffered severely from nausea, vomiting and weakness, the mate being the worse of the two. Both men had to be taken to hospital where the mate died after some ten hours: the lead burner recovered. No details of post-mortem findings are given by Middleton except that there were signs of respiratory failure. Middleton holds that death in this case was due to absorption of the chlorohydrin through the skin.

It will be observed that all the cases referred to in these reports were of the acute kind, that both Koelsch's fatal cases were already far from healthy subjects before the toxic event, that no clear picture emerges as to the cause of death, and that no histological evidence was obtained. It seems to us that Koelsch's two fatal cases died from cardiac failure. The symptoms of nausea and vomiting with sometimes giddiness and even mild signs of

* Ethylene chlorohydrin is 2 monochloro-ethyl alcohol (2 chloro-ethyl alcohol). Its chemical formula is CH_2Cl-CH_2OH. It is a colourless, mobile liquid with an odour difficult to describe but resembling a mixture of ethyl alcohol and ether. Sp. Gr. $1{\cdot}213\frac{20°}{4}$.

It occurs in the chemical industry mainly in the manufacture of ethylene glycol and is widely used as a reactant in many organic syntheses. It is miscible in all proportions with water, ethyl alcohol, and ether. The boiling range of the highly purified material is found by us to be 129·1° C.–130·3° C. at 766 mm. Hg pressure.

narcosis are indicative of central action of the toxic materials. It will be seen that as far as human material is concerned, the cause of death is not entirely clear.

Koelsch's animal experiments deserve summary. He used two groups of animals: 1 cat and 2 guinea-pigs for acute exposures to ethylene chlorhydrin vapour, and 1 cat and 1 guinea-pig for chronic exposure. Of the former group, the cat was exposed to a concentration of 0·0045 g./lit. for 5½ hours daily for two successive days, when it showed general depression, slow and laboured respiration, the side position, repeated vomiting and it was unable to stand: death occurred 3 hours after the second exposure. Post-mortem examination revealed injected and collapsed lungs, tightly filled heart with some sub-epicardial petechiae and marked sub-endocardial haemorrhages: the liver and kidneys were congested and the brain showed punctiform haemorrhages. Microscopic examination confirmed these naked eye observations with, in addition, fine fatty deposits in the renal cortex, and granular masses in the tubules with some shadows of red blood cells. One of the guinea-pigs in this group was exposed to 0·0026 g./lit. during two succeeding days for 2½ and 8 hours respectively. Death occurred during the second night and post-mortem examination showed hyperaemic lungs, tightly packed auricles and punctiform haemorrhages in the brain. Microscopic examination confirmed these findings with, in addition, epithelial detachments in the trachea, globules of fat in the cardiac muscle, epithelial casts in the renal tubules and nuclear degeneration in the cells of Henle's loops. The second guinea-pig in this group was exposed for 15 minutes to a concentration of 0·0182 g./lit. and died after 30 hours. The post-mortem findings in the animal were similar to those observed in the former animal with, in addition, fatty degeneration of the liver.

Chronic effects were observed in a cat exposed to a concentration of 0·0025 g./lit. for 3 hours a day during 4 days. The animal showed some depression and loss in weight but no definite signs of illness until on the fourth day it vomited frequently and death followed. Macroscopically no great changes were noted except albuminuria and hyperaemic lungs, liver, and kidneys, but microscopically the kidneys showed breakdown of nuclei, the liver some nuclear degeneration, cellular swelling and some fatty changes in the lobules, whilst the lungs showed foci of bronchopneumonia and oedema.

A guinea-pig exposed to 0·0022 g./lit. for 3 hours a day during 4 days in one week and in the following week for 4 hours a day during 4 days (i.e. total of 28 hours during 21 days) lost weight, refused food and died. Examination of organs revealed pulmonary oedema and bronchopneumonia with hyperaemia of liver and kidneys.

In discussion of his findings, Koelsch emphasizes the fact that his animals showed no significant signs of illness during the period of exposure, these appearing some time after removal from the exposure chamber, death usually occurring during the night. The post-mortem findings are interpreted as indicating *death from asphyxia*, attention being specially drawn to local irritation of the deeper respiratory passages, fatty changes in the cardiac muscle, liver, and kidneys. The loss in weight observed in his chronic experiments, he holds to be due to diminished food intake and perhaps also to specific metabolic disturbances. He concludes that ethylene chlorohydrin belongs to the metabolic poisons with special effects on the nervous system.

Experiments carried out at Koelsch's instigation confirmed that during an hour's exposure there were no significant signs of severe toxic action and only hours after removal from the chamber were the following signs observed: tremors, incoordination, paresis of extremities, later marked paralysis with side position, death occurring after several hours from respiratory paralysis. Cats showed vomiting, diarrhoea, paralyses, disturbances of equilibrium, sluggish dilated pupils sometimes with nystagmus, sometimes clonic spasms: death was due to respiratory failure. These workers (not named by Koelsch) stated that the nervous symptoms dominated the clinical picture in animals, but examination of tissues showed fatty changes in the liver and, in chronic experiments, nephritis. Changes in the lung were considered not striking and held to be secondary. Like Koelsch they found the compound could be absorbed through the skin.

In spite of the manifestly dangerous properties of ethylene chlorohydrin, no cases had been recorded in Koelsch's factories during twenty years of manufacture, a fact to be attributed to the totally enclosed plant effectively preventing any significant escape of vapour. In none of the cases cited above were the workers engaged in manufacture of the compound. The cases we shall describe were all engaged in manufacture. In Koelsch's and Middleton's cases the course was acute ; in our cases the course was both acute and chronic.

Cases in Present Series

Case 1. G. D., aged 45 years. Foreman.

This man was a foreman of high repute and had been engaged on this particular plant for some thirteen years and was well acquainted with all the regulations, particularly that against the operation which he performed and which led to his death. The circumstances were as follows:—

Owing to a fault in a concentration tower for ethylene chlorohydrin, the foreman decided to find the cause of the trouble and to open an inspection door at the top of the tower. To perform such an operation whilst the tower was full of hot vapour was most strictly forbidden, but the foreman with the aid of a process worker did perform it, and in spite of what must have been an immense concentration of chlorohydrin and ethylene dichloride, managed to make the necessary adjustment, with the result that the process continued without obstruction. The incident occurred during a night shift in November, and the total time during which exposure to a high concentration of vapour continued was about 1½ hours. Half an hour later the process worker stated to the foreman that he felt sick and noticed that the latter looked ill. The process worker, whose exposure to the vapours had been much less severe, seems to have suffered no further, but the foreman,

on taking a cup of tea, was violently sick but was able to walk to the ambulance room an hour after the end of the exposure. Here he vomited and retched repeatedly and was very restless, refusing to lie down.

Two hours after the exposure he was still able to converse intelligently with the first-aid attendant but was still very sick, vomited bile, and was unsteady on his legs. The situation did not apparently strike the attendant as serious enough to call the medical officer at his home until some 3½ hours after the end of exposure. Attempts to take a mixture containing a small dose of morphia were at first unsuccessful, but when some had been retained (probably about ⅛ grain), the vomiting ceased and the patient became more comfortable and fell asleep. One and a half hours later the attendant noticed that the pulse was very weak. The doctor then appeared and found the patient very ill and unable to respond to questioning. The pulse was thready, poor in volume, and weak. Oxygen was administered through a B.L.B. mask, but this seemed to make him more restless with twisting and turning of the head from side to side and restless movements of the limbs. The pupils varied in size from pin-point to extreme dilation over periods of 2 or 3 minutes. Tendon reflexes were very sluggish. The blood-pressure, taken on three occasions, was difficult to read and the doctor considered it to be below 60/40. Some slight improvement of the cardiac action was obtained by injection of coramine and the patient seemed quieter. There were no abnormal physical signs in the chest other than a few râles at the base of the lungs. Throughout there was profuse perspiration. No urine could be obtained. Treatment in the ambulance room was continued on general lines with oxygen administration, but 11½ hours after the end of exposure there was a turn for the worse. He was taken to hospital where he was put into an oxygen tent, but deteriorated rapidly and died 14 hours after the end of exposure to the toxic vapour. It is relevant to point out that on previous occasions this man had minor attacks of vomiting whilst engaged on this plant.

The autopsy report was in substance as follows:—'The body was that of a man of very good average development and nutrition. Nothing abnormal was discovered in the mouth, oesophagus or gastro-intestinal canal. The respiratory system, except for congestion of the tracheal mucous membrane, showed nothing abnormal. The heart was of average size with numerous petechial haemorrhages of the pericardium. The kidneys, liver, spleen, and pancreas appeared normal. The brain showed slight congestion of the cerebral cortex and marked oedema of the cerebral hemispheres. Death was held to be due to toxaemia from inhalation of poisonous fumes.'

A few sections of organs were sent to us and the following observations made: Lung—marked and extensive collapse, oedema, and great extravasation of blood into the alveoli (Fig. 1); liver—isolated areas of degenerative change: fatty degeneration, loss of cellular outlines and disappearance of nuclei; heart—cross-striation could not be seen: otherwise the muscle seemed normal; brain—the single section of brain tissue showed no significant changes.

It is not easy from these data to decide what the decisive pathological change was which caused death. We are inclined to lay stress on the cerebral oedema, but whether this was a primary phenomenon due to attack of the toxic material on the vascular apparatus of the brain or secondary to organ changes, cannot be decided. Certain it is that neither the lung or liver changes were sufficient in themselves to cause death in so short a time. Kidney sections were not available.

Case 2. P., aged 40 years. Process worker.

This case occurred in another factory where ethylene chlorhydrin was being manufactured and where the workers were examined clinically both on engagement and subsequently.

On engagement the medical report was that he was a normal healthy man. He was examined, after entry, on four occasions in 7 weeks. Immediately prior to the last examination he had been behaving 'in a peculiar manner' on the plant. Urine and blood-pressure were normal. On the day following the last examination at the factory he visited his private doctor who diagnosed influenza. A week later, i.e. 2 months after starting, he went for a walk and collapsed in the street. He returned home to bed and complained of headache, dizziness, and vomiting. Two days later he left his bed and again collapsed in the street with similar symptoms. Four days later, his headache had become very severe and his mental condition very muddled; he was removed to hospital. While in hospital no definite physical signs were found, the urine was normal, and B.P. had fallen from the previously-recorded value of 140/90 to 120/80. Nine days after entry into hospital there was haematuria and death occurred on the following day, i.e. 11 weeks and 2 days after starting on this work.

The autopsy report was not satisfactory. Histological examination of tissues showed:—Heart and stomach—no abnormal features; spleen—congested and slightly hyperplastic; kidney—congestion affecting both glomeruli and interstitial tissue: convoluted tubules were severely damaged and showed necrotic changes with much debris in the lumen of the tubules, together with some blood cells; brain—a section from the basal ganglia showed gross oedema: the cells in this area showed degenerative changes. Unfortunately no lung or liver tissues were preserved.

The data on this case are somewhat deficient, but there could be no reasonable doubt that this man had been exposed some 2 months to concentrations of ethylene chlorohydrin (probably mixed with some sym-dichloroethane) which had produced symptoms of greater or less severity in a good many other workers. But in this case the fatal issue after only 11 weeks gives support to the suspicion of Koelsch that there is individual susceptibility. The man was, at the time of his entry, a normal healthy person, and there is no evidence that he had any greater exposure to the vapour than others working on the plant. This is quite different from case 1 in which the concentration of vapour to which the foreman was exposed was extremely high and would probably have proved fatal to anybody.

The cerebral symptoms were very marked in case 2. It is remarkable that no significant physical signs were observed in hospital, except the fall in blood-pressure. The sudden renal haemorrhage shortly before death has not been recorded in any

previous case, but the pathological changes in the kidneys of experimental animals (*vide infra*) render such a sign always a possibility. How far renal failure may have contributed to death cannot be said, but the absence of signs seems to make this improbable.

In this case also the case for attributing the death to cerebral changes seems to us good, but whether this is a primary effect of the poison or secondary to organ changes, which in the case of the kidneys were very severe, cannot be stated with certainty.

The following non-fatal cases are recorded in order to show the general features of the clinical picture which may be regarded as of little significance unless the relation to the toxic compound is realized. These cases occurred during a period in which a fault had developed in the plant; the average concentration of ethylene chlorohydrin in the atmosphere was about 18 parts per million.

Case 3. W. J. H. Male, aged 47 years.

This was a rather unhealthy type of man and alcoholic. While at work on a winter's day he developed headache, nausea, epigastric pain, and vomiting. He reported to the ambulance room but did not appear very ill. Vomiting became more severe and having passed a bulky motion, he suddenly collapsed into a state of stupor, from which, however, he could be roused. On examination his colour was very bad, the pulse was 68 and feeble. The heart was not enlarged and cardiac sounds were feeble. B.P. 100/80. A few scattered rhonchi were noted in the lungs and there was epigastric tenderness. There was generalized weakness. Cranial nerves and tendon reflexes were normal. The urine contained a trace of albumen. Coramine and strychnine injections were not followed by improvement. Administration of oxygen led to some improvement. He was removed to hospital by ambulance, where he collapsed again and received more oxygen. Recovery was slow and he was discharged from hospital after 10 days. B.P. on discharge was 140/90.

Case 4. N. Y. Female, aged 40 years.

This woman was of poor physique, but nothing specifically pathological could be recorded about one month before the present occurrence, when, with several others, she complained of abdominal pain and nausea. On going home from work, she began to vomit: this continued ' all night ' but there was no collapse. She continued to experience nausea and anorexia for 7 days. Urine contained a trace of albumen. On return to work after this period, B.P. was 120/100, urine was normal, and general condition was fair.

Case 5. I. F. Female, aged 30 years.

Normal physique. In similar conditions to previous cases (3 and 4). Experienced nausea and vomited for some hours. Recovered after rest and ceased work for 3 days, after which she appeared quite normal.

Case 6. K. S. Female, aged 24 years.

Good physique when examined prior to engagement. Mildly affected: vomited once or twice. Went home to bed but returned fit to work next day.

Case 7. B. D. Female, aged 25 years.

Good physique on examination prior to engagement. Mildly affected: nausea and vomiting. After rest at home returned to next shift.

Case 8. S. M. Female, aged 34 years.

Good physique. Slightly exposed but vomited profusely. Lost 3 shifts but there were no physical signs on return to work.

Case 9. S. T. L. Male, aged 47 years.

Good physique. Slightly affected. Nausea and vomiting for some hours. No other abnormal signs. Returned to work next shift.

Case 10. A. S. Male, aged 43 years. Fitter's labourer.

Poor physique, poor vision, bad teeth. B.P. 130/90 at time of engagement. When working on a night shift, felt sick at midnight but continued work for 2 more hours. Went to ambulance room with nausea, epigastric pain, and copious bilious vomiting. Treated by first-aid attendant with hot drinks, sodium bicarbonate, warmth, and rest for some 5 hours. Condition was not considered serious, but when allowed to rise from bed and dress, he collapsed. Very drowsy but could be roused. From time to time there was uncontrollable copious vomiting. Patient became cold, clammy, and shivered: grey-blue in colour: pulse 70 and feeble. Some 3½ hours later a bulky foul-smelling motion was passed and patient became alarmingly collapsed.

The medical officer found the patient sleepy but able to answer questions. Pulse 70 with very poor volume. Face grey-blue in colour, erythema over arms and trunk. Tremor of hands and head; loss of power in limbs. Cranial nerves and tendon reflexes normal; no sensory loss. The heart was normal in size; poor apical impulse and second sound could not be heard; B.P. 60/40. Pulmonary system apparently normal. Teeth very bad; tongue thickly coated with yellow, moist fur. Abdomen not tender but rigidity in right epigastrium. Liver one inch below costal margin. Urine showed faint trace of albumen. Treated with continuous oxygen through a B.L.B. mask with slow improvement.

Next day there were no abnormal physical signs; B.P. 100/70.

On the following day patient felt very well; B.P. 140/90.

Case 11. P. S. Male, aged 46 years.

Poor physique, very bad teeth. B.P. 140/100.

As in other cases, he complained during work of nausea, abdominal pain which later was accompanied by vomiting and an irritant cough. Treated in ambulance room with rest and warmth and improved symptomatically. Some hours later was transported home where he experienced intense headache, giddiness, and insecurity on his legs. Went to bed: vomited and defaecated and fell into a long sleep. On examination some hours later he was sleepy, complained of headache and there was a scarlet rash on the trunk: pulse 70, B.P. 100/70. Tongue was furred but moist; throat was injected and right epigastrium was tender. Liver was not palpable. Lungs showed a few scattered rhonchi. Nothing of significance in C.N.S. Urine showed trace of albumen.

Next day, great improvement: appetite returning: B.P. 140/100.

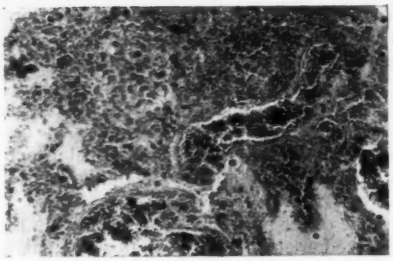

FIG. 1.—Lung of case 1 (human). H. and E. × 120.

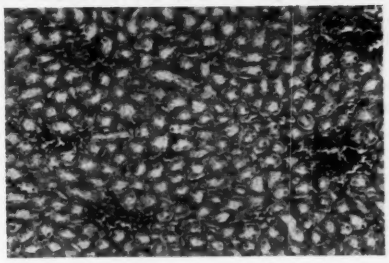

FIG. 2.—Kidney of rat exposed to 0·010 g./litre for 30 minutes. H. and E. × 120.

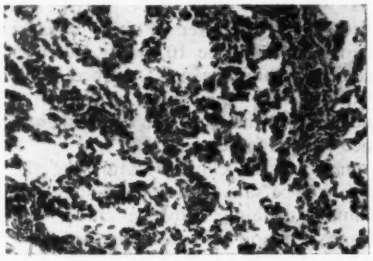

FIG. 3.—Lung of rat exposed to 0·003 g./litre for 15 minutes on three successive days. H. and E. × 120.

FIG. 4.—Kidney of rat exposed to 0·003 g./litre for 15 minutes on six successive days. H. and E. × 120.

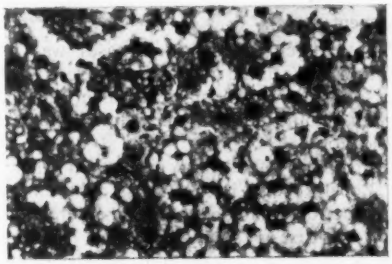

FIG. 5.—Liver of rat exposed to 0·003 g./litre for 15 minutes on eleven successive days. H. and E. × 375.

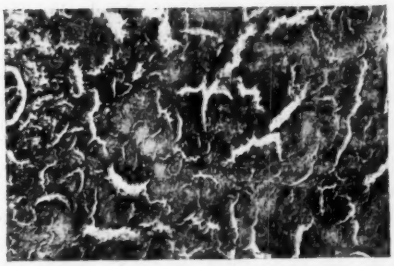

FIG. 6.—Kidney of rat exposed to 0/003 g./litre for 15 minutes on eleven successive days. H. and E. × 120.

Discussion of Signs and Symptoms

Summarizing signs and symptoms in these non-fatal cases, we have:—

Digestive system.—Nausea, epigastric pain, repeated vomiting (bile may appear), bulky offensive stools.

Circulatory system.—Depressor action on the circulation. Signs of shock in severe cases.

Nervous system.—Headache, giddiness, incoordination, confusion, mild narcotic effects.

Urinary system.—Slight albuminuria, disappearing on recovery, polyuria.*

Respiratory system.—Cough may be present. Rhonchi.

Skin.—Erythema on skin of arms and trunk in severe cases

* Some men complained of loss of sexual potency but it is difficult to interpret this complaint.

Symptoms and signs were worst in men of poor physical standard. Recovery in these non-fatal cases was complete; and in all except one (case 3) it was rapid.

From the nature of the work, it is certain that the route of absorption was the respiratory tract. The vapour absorbed was a mixture of ethylene chlorohydrin and ethylene dichloride, but the very minor narcotic effects observed lead us to believe that the latter was not the principal cause of the symptoms. The possibility of summation of toxic effects cannot be ruled out, and hence we cannot assert with certainty that the ethylene dichloride present was not involved in the production of symptoms. It is impossible with the data at our disposal to do more than suspect that ethylene chlorohydrin was the main toxic agent involved.

Since the events described above, regular estimations of ethylene chlorohydrin and ethylene dichloride in the atmosphere of the plant have been carried out. According to the results obtained, appropriate action is taken. The figures given in the table below (Table 1) show a marked improvement in conditions on one plant which was accompanied by definite falling off of symptoms of absorption by the workers. From the experience gained with these and from mild subsequent cases it seems to us that women are somewhat more liable to develop symptoms than are men.

The nature of the symptoms is clearly non-specific. Any of these signs and symptoms may be met with in poisoning by many of the chlorinated aliphatic hydrocarbons. This renders it difficult for us to be certain as to the relative importance to be attached to ethylene chlorohydrin and ethylene dichloride, to both of which all our cases were undoubtedly exposed (*vide infra*).

The course of the intoxication is such as to point to cumulative action and also to considerable delay between the actual exposure and the onset of symptoms. Even in the acutely fatal case (case 1) collapse did not occur during the exposure. Similarly with the mild cases in which symptoms often appeared only after the worker had reached home.

The regular occurrence of nausea and vomiting cannot be attributed to offensive or sickly odours. Men, who had worked previously on most offensive chemical processes without gastric disturbance, experienced these symptoms when on ethylene chlorohydrin. The odour of a mixture of ethylene chlorohydrin and ethylene vapours is characteristic but not frankly nauseating. Indeed, after a period in the shed the odour is no longer noticed. Hence we are of opinion that both the nausea and vomiting are central in origin.

The fall in blood-pressure noted in so many of these cases is an accompaniment of many intoxications with organic vapours. It will be shown below that ethylene chlorohydrin, in high concentration, inhibits the heart both by direct action on the muscle and possibly also by some action on the vagal mechanism. The frankly cerebral symptoms, even to the point of psychological disturbance, leave no doubt as to the attack on the higher centres. The mild narcotic effect occasionally recorded was probably to be attributed mainly to the presence of ethylene dichloride. The occurrence of cerebral oedema in both fatal cases is additional evidence of toxic action on the vascular system, as are also the pericardial petechiae.

In none of the mild cases here recorded was there any marked attack on the respiratory system, but in case 1 the effect on the lungs was very evident. The presence of slight albuminuria even in the mild cases is significant, and in case 2 the toxic effect on the kidneys was very marked. Clinical evidence of toxic action on the liver in these cases was not obtained except in case 10, when there was some enlargement of the organ. Evidence from animal experiments with ethylene chlorohydrin shows marked effect on the liver. In case 1 there was also evidence of hepatic degeneration.

Summarizing the clinical features of the above cases, it may be said that the principal toxic agent was almost certainly ethylene chlorohydrin and that its toxic action in man is directed towards the nervous system, the cardio-vascular system and the kidneys: the secondary points of attack are the lungs and the liver. No irritant effects on the skin, eyes, and mucous membranes were observed.

Treatment

The treatment of all these cases was entirely symptomatic. In the mild cases recovery was in the main spontaneous, any measures taken being general and not significantly influencing the course of the intoxication.

The absence of physical signs even when as in case 2 death occurs later, renders it extremely difficult to decide what therapeutic measures are indicated. In case 1 some temporary improvement could be obtained by continuous oxygen administration and analeptics.

TABLE 1

CONCENTRATIONS OF ETHYLENE CHLOROHYDRIN (E.C.) AND ETHYLENE DICHLORIDE (E.D.) AT VARIOUS POINTS ON A PLANT WHERE MILD SYMPTOMS HAVE BEEN OBSERVED AMONGST THE WORKERS.

Sampling Point *	6th November, 1941		9th/10th April, 1942		6th/7th May, 1942		2nd/3rd July, 1942	
	E.C.	E.D.	E.C.	E.D.	E.C.	E.D.	E.C.	E.D.
	Parts per million. Vol./vol.							
1.	25	72	9	24	10	36	5	36
2.	8	15	9	84	10	48	5	48
3.	24	95	15	60	10	48	5	48
4.	16	152	20	143	10	72	5	24
5.	49	24	15	48	15	84	5	12
6.	20	131	25	72	20	84	0	48
7.	2	2	5	12	5	12		

* Sampling was carried out during the night shift.

Much more information on the nature of action of substances of this kind is required before a proper indication to treatment can be laid down.

Prevention

The usual formulae as to prevention of toxic events apply here, viz. that leaks, overflows, and escape of vapour should be avoided: good ventilation, draughting specially hazardous points, regular medical examination of workers, report by workers of untoward symptoms, detection of susceptible subjects, routine estimation of concentration of vapours at working places are all required. The main problem, as always, is design of plant. The necessity for periodic sampling from reaction vessels requires arrangements for sampling which do not involve the opening of points where escape of fume is inevitable.

The fact that ethylene chlorohydrin appears to be a cumulative poison renders it of the first importance to prevent even low concentrations in the atmosphere: we take the view that no concentration that is chemically determinable should be regarded as satisfactory. Table 1 shows the improvements obtained on one plant when the insidious nature of the poison was recognized as a result of experience in other similar places.

The improvement in the concentrations of ethylene chlorohydrin was very striking and resulted from simple plant measures and not from significant improvement in ventilation (in present circumstances the latter is seldom possible). The target set for ethylene chlorohydrin in the atmosphere is 2 p.p.m. but the attainment of this is likely to be very difficult.

This improvement has been followed by much diminution in the incidence of signs and symptoms among workers; but it is necessary to realize that where ethylene chlorohydrin is a toxic risk, determination of concentrations in the atmosphere must be continued as a routine as long as the process is continued.

Summary

1. Two cases of death attributed to poisoning by inhalation of ethylene chlorohydrin vapour are described. One case was very acute in its course, the other sub-acute. The causes of death were not clear, but the associated symptoms and some histological evidence suggest that the compound is a violent cerebral and vascular poison. Pathological changes in the lungs, kidneys, and liver were marked.

2. Nine cases of non-fatal poisoning due to inhalation of the vapour are shortly described. The symptoms noted were non-specific and associated with all the main physiological systems in greater or less degree. Indications were obtained that men of poor physical standard are more readily affected than good specimens: women are thought to be more susceptible than men.

3. Some evidence was obtained that the substance is a cumulative poison.

4. It is held that in all processes in which ethylene chlorohydrin is used or appears as an intermediate stage in manufacture, every possible measure must be taken to control the concentration of the vapour in the atmosphere, since no concentration of the compound is considered safe if exposure is a daily occurrence. The diminution in the incidence of cases is soon manifest if even simple precautions are taken.

5. Treatment is purely symptomatic in severe cases. Mild cases in general soon recover but the likelihood of repeated attacks is always to be kept in mind. Some degree of personal idiosyncrasy is suspected.

Our thanks are due to Dr. Charles Cresdee for certain of the clinical data.

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Part II.—EXPERIMENTAL

BY

M. W. GOLDBLATT

The cases first recorded by Koelsch (1927) undoubtedly occurred because of the lack of knowledge of the toxic properties of ethylene chlorohydrin, which could have been realized by animal experiment. The very fact that the plant in which it occurred (probably as an intermediate in the manufacture of ethylene glycol) was so efficiently enclosed that no cases had been observed for 20 years, gave a false security which was dispelled only when clinical cases were met with during the utilization of the compound in open conditions. Whether these cases were indeed entirely due to the chlorohydrin it is difficult to say, for admixture with ethylene dichloride and even dichlor-diethyl ether seems highly probable, since the preparation of pure ethylene chlorohydrin requires considerable care and would probably not be worth doing for crude industrial purposes.

Our cases (see Part I) were certainly exposed to all three compounds, but the amount of the dichlor-diethyl ether was extremely small. We, also, were in a state of false security because of the absence of unfavourable events throughout years of manufacture.

As has already been stated, the relative parts played by the chlorohydrin and the dichloride in the production of the symptoms cannot be stated with certainty.

Toxic effects of ethylene dichloride appear to be very rare, but Browning (1937) refers to a case (reported to the Home Office in 1932) of a worker who, fitting a coil in a glycol plant, complained of vomiting, diarrhoea, giddiness, and drowsiness. We imagine that the attribution of this case only to ethylene dichloride was not justified and that ethylene chlorohydrin was also involved.

Flury and Zernik (1931) state that ethylene dichloride is a narcotic with mild local irritant properties, and that in man inhalation of the vapour produces a burning sensation in the throat, cough, and later vomiting, and go on to say that more severe symptoms than these had not at that time been reported.

For the purpose of experimental study, we have regarded ethylene chlorohydrin as the substance calling for attention and the following experiments deal mainly with it. The closest chemical relatives of ethylene chlorohydrin are ethylene glycol, ethyl and ethylene dichloride (sym-dichloroethane) and ethyl chloride.

A.

CH_2OH	CH_2OH	CH_2OH	CH_2Cl	CH_3
CH_2OH	CH_3	CH_2Cl	CH_2Cl	CH_2Cl
ethylene glycol	ethyl alcohol	ethylene chlorohydrin	ethylene dichloride	ethyl chloride

In an investigation carried out many years ago, Marshall and Heath (1897) studied the physiological properties of a series of compounds similar to these, viz.,

B.

$\left.\begin{matrix}CH_2OH\\ \vert\\ CH.OH\\ \vert\\ CH_2OH\end{matrix}\right\}$	CH_2Cl $\vert$ $CHOH$ $\vert$ CH_2OH	CH_2Cl $\vert$ $CHOH$ $\vert$ CH_2Cl	CH_2Cl $\vert$ $CHCl$ $\vert$ CH_2Cl
glycerol	α-mono-chlorohydrin	α-γ-dichlorhydrin	α, β, γ tri-chlorohydrin

They worked with a view to elucidating the effects of the introduction of the chlorine atoms into the molecules, and found that whereas the trichloro compound was a powerful hypnotic, the monochloro compound was hardly narcotic at all. All the chlorinated derivatives produced a fall in temperature, slowing respiration and pulse-rate in rabbits. Administration by the mouth of 1 g. per kg. was more or less rapidly fatal in all cases. Special reference was made to the fact that with the monochlor compounds there was a great delay in the appearance of nervous symptoms in spite of its great solubility. Intravenous injection into anaesthetised rabbits led to a transient fall in blood-pressure, the depressor action increasing with the number of chlorine atoms. The authors held that this effect was in part due to vasodilation rather than to action on the heart muscle. Vasodilation was demonstrated by perfusion of sheep's kidney through the renal artery, and measurement of minute volume delivered from the renal vein. Perfusion with a concentration of 1 in 1,000 produced vasoconstriction in all cases, but at 1 in 5,000 vasodilation was evident and most marked with the trichloro compound.

Perfusion of the isolated frog's heart with the monochlor at 1 in 1,000 had no effect, and at 1 in 100 there was only slight diminution of systole; the dichlor had a more marked effect of the same kind, and the trichlor at 1 in 1,000 depressed the heart and markedly diminished systole, but diastole was complete. In all cases normal activity was re-established on washing the heart through with the normal perfusion fluid.

Toxic effects on voluntary muscle (frog's gastrocnemius) were readily demonstrated and increased with increasing numbers of chlorine atoms.

The authors concluded that these chlorinated compounds act as direct poisons of protoplasm and that this property increases in intensity as the number of chlorine atoms is increased. It is to be observed that as the chlorination is increased, the solubility in water diminishes until the trichloro compound is almost insoluble.

The decrease in solubility is related to the diminishing number of hydroxyl groups. The same progressive diminution in water solubility also obtains in the series of compounds A. until with ethylene dichloride we have relatively almost complete insolubility (1 in 1,000 at 20° C.).

All the compounds B. are liquid, and as to their effects on man, nothing can be said except as to glycerine which is for practicable purposes non-

TABLE 1

LETHAL DOSES

	Ethylene glycol	Ethyl alcohol	Ethylene dichloride	Ethylene chlorohydrin
By mouth	*Rat* 10–11 g./kg. tolerated	*Rat* 9–10 g./kg.	?	?
Intraperitoneal	*Rat* 5–6 g./kg. tolerated 11 g./kg. fatal	*Dog* 3–5 g./kg.	?	?
Subcutaneous	*Mice* 2·7 g./kg.	*Mice* 4–5 g./kg.	?	?
Inhalation	*Rat* 0·5 mg./l. not fatal (exposure 28 hours in 5 days)	*Rat* 19–24 mg./l. in 21 hours 85 mg./l. in 4½ hours *Guinea-pig* 85 mg./l. in 10¾ hours	*Mice* 35 mg./l. in 2 hours 100 mg./l. in ½ hour *Guinea-pig* 40 mg./l. for 25 min. fatal next day. 240 mg./l. in ½ hour	*Guinea-pig* 2–3 mg./l 28 hours' exposure during 2 weeks ; fatal *Cat* 2–3 mg./l. 3–4 hours every other day for 4 days; fatal

toxic, and indeed enters into the metabolism of the organism by forming glycogen.* Of the series A, all are liquid and all are in greater or less measure toxic. The increased toxicity when the chlorine atom is introduced is very striking.

Exactly comparable figures are difficult to find in the literature, but Table 1, drawn up from Browning's review on industrial organic solvents (1937), gives some idea of the different toxicities in animals.

As regards acute toxicity, these figures indicate, with reservations, that ethylene glycol is less toxic than ethyl alcohol when given to rats by mouth, but apparently more so when injected subcutaneously in mice. The relative toxicities of the vapours are also difficult to conclude upon. For ethylene glycol, experiments on exposure to the vapour have really little significance, but the figures on the effect of the vapours of the remaining substances on the guinea-pig leave no doubt that ethyl alcohol is much less toxic than the two chloro compounds, the more so as the guinea-pig is rather resistant to the action of narcotic vapours.

Müller (1925) gives results on chlorinated hydrocarbons and in particular ethylene dichloride which are readily comprehended. Mice were used and the following results (Table 2) obtained with ethylene dichloride:—

TABLE 2

Weight of mice, grams	Concentrationof vapour, mg./litre	Time to side position, mins.	Period of exposure, mins.	Results
15	11·5	—	123	Dead in 1 day
18	23	40	54	Dead in 1 day
15	23	—	70	Dead in apparatus
17·5	57	—	36	Dead in apparatus
20	114	—	15	Moribund next day

The concentrations of vapour used by Müller are too high to give a true picture of the toxicity. The striking characteristic of the effect of ethylene dichloride is that after full narcosis at a relatively low concentration, the animals recover apparently completely but are found dead some hours later, usually next day: the substance is also lethal at concentrations below the narcotic.

No table of results comparable to the above is extant for ethylene chlorohydrin, as far as we know.

EXPERIMENTS

1. Effects of Ethylene Chlorohydrin Vapour on Animals

For this purpose we used a simple apparatus consisting of a gas meter, flow meter, constant dropping apparatus, vaporizing chamber, mixing, and exposure chamber and a suction system. Within reasonable limits of error the concentration of vapour could be calculated for any rate of dropping and flow of air. In general, the flow of air was kept at between 8 and 10 litres per minute and the rate of dropping could be kept steady at from 1 drop per second to 1 drop per minute.

The exposure chamber was a large dessicator suitable for mice, rats, or guinea-pigs. Symptoms were carefully observed during exposures and for several hours after. In many cases the time of death could not be accurately determined as it occurred during the night. In all our experiments the ethylene chlorohydrin and ethylene dichloride were pure.

The following table (Table 3) shows the results of some typical experiments.

The lesser sensitivity of the guinea-pig to the vapour is shown by the fact that exposure for 55 minutes to 0·005 g./litre is not lethal, whereas 0·0039 g./litre for 15 minutes is fatal to 2 out of 3 mice after 2 days and 0·004 g./litre for 30 minutes is fatal to all rats.

The point made by Koelsch that animals do not

TABLE 3

SINGLE EXPOSURES OF ANIMALS TO THE VAPOUR OF ETHYLENE CHLOROHYDRIN

Density of ethylene chlorohydrin liquid: 1·204.
Boiling range: 129·1° –130·3° C.
0·001 g./litre=280 parts per million v/v.

Number of animals		Average weight, grams	Conc. of vapour, g./lit.	Time to side position, mins.	Total exposure, mins.	Results
Mice	3	23	0·001	—	120	Non-lethal
	3	23	0·003	—	60	3/3 dead next day
	3	23	0·0032	—	60	3/3 dead next day
	3	21	0·0039	—	15	2/3 dead after 2 days
	3	21	0·0039	—	120	3/3 dead in 140 to 170 mins.
	3	21	0·0045	—	30	3/3 dead next day
	3	21	0·0052	—	60	3/3 dead in 100 mins. to next day
	3	20	0·007	80	120	3/3 dead in 110–129 mins.
Rats	3	115	0·003	—	15	Non-lethal
	3	120	0·004	—	30	3/3 dead next day
Guinea-pigs	1	450	0·003	—	30	Non-lethal
	1	350	0·003	—	112	Dead next day
	1	450	0·039	—	108	Dead next day
	1	450	0·005	—	55	Non-lethal

* The author has drunk 100 gms. of glycerol in water without toxic effects, other than some temporary irritation of the bowel.

die during exposure is borne out by our findings, although in the case of one mouse exposed to 0·007 g./litre death did occur in the exposure chamber after 110 minutes, whilst the two remaining animals died a very few minutes later. The side position recorded at this last concentration after 80 minutes exposure was really the rolling over of the animals on to their sides as death was imminent and not a manifestation of narcosis.

Since we are interested to determine whether the gross toxicity of ethylene chlorohydrin is greater or less than that of ethylene dichloride, the following results are recorded from experiments performed as in Table 3 for both ethylene chlorohydrin and ethylene dichloride.

For comparisons of this kind it is essential to work at as low concentrations as possible.

Our results have satisfied us that ethylene dicloride vapour is markedly less toxic for these animals than is ethylene chlorohydrin. It is to be noted that narcosis was not produced at any of the concentrations recorded. Narcosis can readily be produced with the dichloride at higher concentrations. Attempts to produce narcosis with ethylene chlorohydrin by using higher concentrations simply kills the animals before a true narcosis can be observed.

Symptoms of Exposure to Ethylene Chlorohydrin Vapour. In general the animals were first obviously discomforted. Later the eyes were closed and obvious depression set in with evidence of nasal irritation. After about an hour's exposure to the higher concentrations there was inco-ordination of movement and the animals became very reactive. A loud noise or smart tapping on the side of the exposure chamber stimulated them to an almost convulsive response, after which they lay on their sides with, in the case of rats and mice, the tail at right angles to the body. A true side position was not attained and none of the animals became narcotized.

On removal from exposure, the general appearance often gave the impression that the animals would survive, but fatalities followed as recorded, preceded in some cases by convulsions. The delay in the onset of lethal symptoms is quite characteristic and death when it does occur is sudden and appears to be due to respiratory failure.

Macroscopic examination of the organs gave no obvious indication as to the immediate cause of death.

Histological Examination. Rat exposed to 0·010 g./litre for 30 minutes—dead next day.

Lungs.—Areas of collapse but no haemorrhage or oedema.

Kidneys.—Glomeruli normal: marked haemorrhages between the medullary tubules, blood in part haemolysed; convoluted tubules swollen and in part detached; areas of lost structure (Fig. 2. See p. 211).

Guinea-pig exposed to 0·003 g./litre for 112 minutes—dead next day.

Lungs.—Some areas of emphysema; no haemorrhage or oedema.

Kidneys.—Glomeruli normal; large numbers of haemorrhages mainly at junctional areas between cortex and medulla.

Heart, *liver*, *cerebellum*, and *pons*.—No obvious changes.

It thus appears that the main attack of the vapour of ethylene chlorohydrin in these acute cases is upon the kidney and to some extent the lungs.

Effects of Repeated Exposure to Ethylene Chlorohydrin Vapour. Three rats were used and exposed daily as below. After each exposure the urine was collected in a metabolism cage. The average weight of the animals was 115 g. at the outset. Food and drink *ad lib* throughout.

The animals were obviously depressed, lost weight, but ate when in the metabolism cage. The urine collected daily throughout the experiment gave no evidence of renal disease. Repeated exposure at this concentration (average 0·0034) for 15 minutes a day eventually leads to death of all animals. Individual variability is clearly shown in the table.

Histological examination of these animals showed:—

Rat dying on 3rd day: Intensely congested kidney with here and there beginning haemorrhages;

TABLE 4

COMPARISON OF LETHAL EFFECTS OF ETHYLENE CHLOROHYDRIN AND OF ETHYLENE DICHLORIDE (SINGLE EXPOSURES)

Density of ethylene dichloride: 1·25.
Boiling range: 83·5°–84·2° C.
0·001 g./litre = 226 parts per million v/v.

	Ethylene chlorohydrin			Ethylene dichloride		
	Concn. of vapour, g./litre	Time of exposure, mins.	Result	Concn. of vapour, g./litre	Time of exposure, mins.	Result
Mice	0·003	15	Non-lethal	0·004	120	Non-lethal
	0·004	30	Lethal next day	0·008	120	Lethal next day
Rats	0·001	120	Non-lethal	0·002	120	1/3 dead next day
	0·003	60	Lethal next day	0·003	120	Lethal
Guinea-pigs	0·003	30	Non-lethal	0·004	118	Non-lethal
	0·003	112	Lethal next day	0·006	115	Non-lethal
				0·007	117	Non-lethal
				0·009	117	Lethal
				0·017	120	Very ill but recovered

intensely congested liver and small areas of collapse in the lungs. (Fig. 3.)

TABLE 5

REPEATED EXPOSURE OF RATS TO VAPOUR OF ETHYLENE CHLOROHYDRIN

Day	Concn. of vapour, g./lit.	Exposure, mins.	Deaths
1	0·003	15	
2	0·003	15	
3	0·005	15	1st death
4	0·004	15	
5	0·003	15	
6	0·003	15	2nd death — loss in weight 25 g.
7	0·004	15	
8	0·0024	15	
9	0·002	15	
10	0·004	15	
11	0·004	15	3rd death—5 hrs. after last exposure

Rat dying on 6th day: Many small haemorrhages in the kidney but glomeruli normal; cells of convoluted tubules disorganized and many detached; cells swollen and nuclei broken down in many cases. (Fig. 4.)

Liver showed fatty changes; cell outlines lost with large areas of replacement of cells by globules of fat.

Lungs showed collapse, areas of haemorrhage, considerable deposition of pigment but no oedema.

Rat dying on 11th day: Lungs showed areas of rupture of alveoli and of collapse; in many parts the alveolar epithelium was swollen sufficiently to occlude the lumen; some deposition of dark pigment; no haemorrhages, no oedema. The liver was intensely congested with areas of complete degeneration; some formation of pigment in medium sized vessels and marked fatty degeneration. (Fig. 5.)

The kidneys showed normal glomeruli, multiple small haemorrhages, complete disintegration of cells of convoluted tubules, cells of Henle's loops much less affected but cells in parts swollen and detached but with apparently normal nuclei. (Fig. 6.)

It appears clear from these findings that the earliest focus of intense attack is the kidney, starting with small haemorrhages and proceeding to widespread necrosis of the cortical cells; the glomeruli were in all cases strikingly normal in appearance. The second point of attack is the liver with fatty degeneration and later extensive breakdown of the cellular structure. The lungs appear to be affected least severely but some areas of haemorrhage and collapse could be made out.

The absence of signs of kidney damage in the urine of these animals is surprising. Secretion of urine was unimpaired. It would appear that the effect of ethylene chlorohydrin on the kidney in these animals is that of a vascular poison and perhaps only secondarily affecting the cells of the secreting tissue, but the entire absence of attack upon the glomerular vessels is extremely puzzling.

No studies of the effects upon blood and urine constituents have yet been made.

We have no data as yet on the structural changes which may occur in the central nervous system.

2. Intraperitoneal Injections of Ethylene Chlorohydrin

Whilst the main risk attaching to this compound in industry is the toxic effect of the vapour, the fact that evidence of absorption through the skin when the liquid is applied can readily be obtained, renders it of some importance to determine the toxic doses of the liquid. The ready miscibility with water makes injection experiments easy.

The following table (Table 6) shows the effect of intraperitoneal injections in rats.

Two groups of rats were taken (24 and 18), one group starved for 24 hours and the others fed on the stock diet.

TABLE 6

SINGLE INTRAPERITONEAL INJECTION IN RATS

Starved 24 hours		Normally fed	
Dose injected intraperitoneally, mg./100 g.	Deaths	Dose injected intraperitoneally, mg./100 g.	Deaths
4	1/4 next day		
5	0/4	5	1/6 next day
6	4/4 after 3 hours	6	6/6 next day
7	4/4 (3 after 3 hours—1 next day)		
8	4/4 after 3 hours		
10	4/4 after 3 hours	10	6/6 (4 after 3 hours—2 next day)

Clearly the L.D. 50 is between 5 and 6 mg./100 g. (5·6 mg./100 g.) and the fact of being fed or unfed makes no significant difference. The figures for the starved animals show that the rat can successfully detoxicate between 4 and 5 mg./100 g. as a single dose. If repeated doses are given very much more can be detoxicated, as shown in the following table (Table 7) :—

TABLE 7

REPEATED INTRAPERITONEAL INJECTION IN ONE GROUP OF 6 RATS

Dose, mg./100 g.	No. of daily doses	Total injected, mg./100 g.	Results
1	8	8	No deaths
2	2	4	No deaths
3	4	12	No deaths
5	1	5	4/6 dead

The six rats were able without symptoms or loss in weight to detoxicate 24 mg./100 g., two survived

even 29 mg./100 g. A single dose of 5 mg./100 g. on the 15th day killed 4 out of the 6. These results seem to militate against any idea of cumulative action.

3. Oral Administration of Ethylene Chlorohydrin

One group of 30 rats were given doses varying from 1 mg./100 g. to 6 mg./100 g. in aqueous solution by stomach tube, and a second group of 18 rats doses varying from 5 mg./100 g. to 10 mg./100 g.

TABLE 8

Dose (mouth) mg./100 g.	Deaths	Dose (mouth) mg./100 g.	Deaths
1	0/2	7	2/3
2	0/2	8	2/3
3	0/2	9	3/3
4	1/8	10	3/3
5	0/8 0/3		
6	2/8 1/3		

L.D. 50 approximates 7·2 mg. per 100 g.

Thus, as is perhaps to be expected, the toxicity by mouth is rather less than by the intraperitoneal route.

The symptoms in the case of the animals which later died were delayed in onset and included general prostration, diminished or absent corneal reflex, intermittent spasmodic movements of almost convulsive type, slowed respiration, fall in temperature and death. At no stage could it be said that the animals were narcotized, except as in the ante-mortem state.

We are at pains to insist on this absence of true narcosis which distinguishes the toxic effects of ethylene chlorohydrin from those of ethylene dichloride which produces true narcosis.

The following experiment with a rabbit also shows the absence of true narcosis and the delayed action.

A rabbit of 2·7 kg. weight was injected intravenously with 100 mg./kg. of ethylene chlorohydrin. Three hours after the injection the animal showed signs of increasing inability to keep the head erect, the animal tending to lay it on one side on the floor of the cage. On disturbing the animal by noise or by raising the head there followed intermittent oscillatory movements of the head until it again was laid in the original position. The animal was 'conscious' throughout. Four hours after the injection the body was very cold; the animal gave a convulsive bound and died from failure of respiration. No obvious cause of death could be found on macroscopic examination of the organs.

The absence of true narcotic action may be compared to the finding of Marshall and Heath (*loc. cit.*) with glycerine monochlorohydrin which had no narcotic effect, whilst the trichlorohydrin was a powerful hypnotic.

The difference in narcotic effects between ethylene chlorohydrin and dichloride can be shown in frogs, although, in general, we do not regard frogs as good subjects for this type of experiment. Injection of 0·1 c.c. pure ethylene dichloride into the dorsal sac leads in 3 or 4 minutes to immobility, flaccidity, extremely slow and shallow respiration; in about 6 minutes the corneal reflex disappears; in 15 minutes reflex to acid disappears; in 20 minutes there follows cessation of respiration, fine muscular tremors over the whole body and death.

Injection of 0·1 c.c. ethylene chlorohydrin into the dorsal sac is followed in about 6 minutes by failure of the righting reflex when the frog is placed on its back, the limbs are drawn tightly to the body, but the corneal reflexes are still present; in 10 minutes the animal still makes inco-ordinated efforts to walk and is still able to jump, although weakly; in 17 minutes it is still able to make slow, spasmodic, progressive movements and corneal reflexes are still present: in 34 minutes the corneal reflex had disappeared, but the reflex to acid, though sluggish, was still present, and there was still extremely slow respiration: after 90 minutes the frog was still making stretching movements and what appeared to be attempts to crawl, but at this stage no corneal reflex could be obtained: the passage to death was almost imperceptible.

The dose in both cases was, of course, immensely high, far exceeding the median lethal dose for frogs, and was used to see if narcosis could be obtained. Smaller doses of ethylene chlorohydrin (250 mg. per kilo) produced no apparent symptoms for many hours but are fatal eventually: 50 mg. per kilo are tolerated.

Smooth narcosis of the frog can be obtained with ethylene dichloride in 2 or 3 minutes by simple exposure under a bell-jar to the vapour from cotton wool soaked in the liquid: removal some few minutes after narcosis is established is followed by recovery.

Exposure to ethylene chlorohydrin vapour produces depression and immobility, but even after 30 minutes at a high concentration, true narcosis is not attained: recovery is very slow with protracted inco-ordination and obviously great depression.

Although the depressant action of ethylene chlorohydrin on the nervous system is apparent, this action is different from narcosis, and seems to be complicated in the intact animal by a certain stimulant or irritant element which prevents full establishment of the latter. The depressant action of ethylene chlorohydrin is readily demonstrable on a variety of physiological processes and tissues.

We have referred in the descriptions of clinical cases (see Part I) to the considerable fall of blood-pressure in man which follows the inhalation of the vapour when in considerable concentration. In the following experiments attempts were made to elucidate the mechanism of this depressor action.

4. Effect of Ethylene Chlorohydrin on the Blood-Pressure and Respiration

It must be stated at the outset that we have failed to produce clear evidence in anaesthetized animals (cats and rabbits) that inhalation of the vapour produces a manifest drop in blood-pressure or significant changes in respiratory depth or rhythm. This was the result obtained whether the vapour was inhaled through the nasal passages or through a tracheal cannula, the vapour being inhaled from a duct leading from a continuous evaporating system. Concentrations of 10–15 mg. per litre (2,800–4,200 p.p.m. v/v) were attained and were inhaled for several hours without any fall in blood-pressure or signs of respiratory disturbance.

We proceed, therefore, to examine the effect of intravenous injection. In one experiment the

effect of ethylene chlorohydrin on the blood-pressure of an anaesthetized cat was examined before and after atropinization. A 3-kilogram cat was anaesthetized with ether followed by intravenous chloralose (80 mg. per kilo). Blood-pressure was recorded from the carotid artery and injections made through the femoral vein. Table 9 shows the course of the experiment. Primary and secondary falls in B.P. were observed, the recovery from the primary fall being due to the asphyxial rise which will be demonstrated in a later experiment.

TABLE 9

EFFECT OF INTRAVENOUS ETHYLENE CHLOROHYDRIN ON B.P. OF ANAESTHETIZED CAT

Initial B.P., mm. Hg.	Injection	Fall in B.P. mm. Hg.	
		Primary	Secondary
160	0·2 c.c.	30	68
144	0·3 ,,	40	46
132	0·3 ,,	42	44
122	10 mg. atropine sulphate intraperitoneally	40	
82	0·2 c.c.	10	16
80	0·3 ,,	8	12
76	0·5 ,,	16	2
72	1·0 ,,	42	Death

Fig. 7 shows the effects clearly. The immediate effect of the large doses used is inhibition of the heart with a resultant immediate drop in blood-pressure: this is accompanied by an ephemeral inhibition of respiration with re-establishment of cardiac action and rise in B.P.: the last phase is a slower fall in pressure with a subsequent slower recovery usually to a level lower than that existing before injection. (Fig. 7 (*a*) and (*b*).)

After full atropinization the effect of similar doses at suitable intervals is to produce so little effect on blood-pressure (Fig. 7 (*c*) and (*d*)), that there seems no alternative but to suppose that the depressor effect is associated with some action on the vagal mechanism. We do not stress the effect on the vagal mechanism since compounds of the type of ethylene chlorohydrin are liable to be responded to in puzzling ways. Very much larger doses (Fig. 7 (*e*) and (*f*)), are now required to produce effects comparable with those found before atropine. The fatal dose of 1·0 c.c. was required to produce a fall comparable to that of 0·3 c.c. before atropine: this was almost at once followed by a violent asphyxial rise and death.

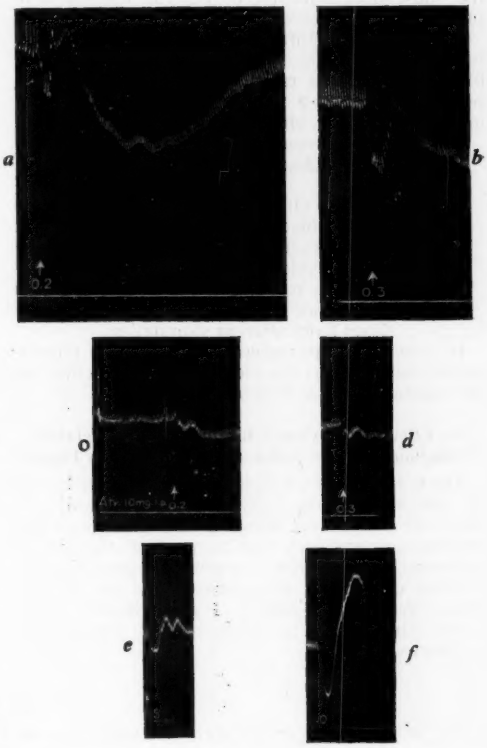


FIG. 7.—Effect of 0·2 c.c. and 0·3 c.c. ethylene chlorohydrin intravenously on B.P. of cat (chloralose), (*a*) and (*b*).

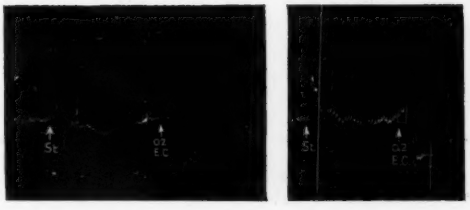
Effect of 0·2, 0·3, 0·5, 1·0 c.c. ethylene chlorohydrin intravenously after full atropinization, (*c*), (*d*), (*e*), (*f*).

5. Effect of Ethylene Chlorohydrin on Vascular Reflexes from Afferent Nerves and Vagal Responses

A cat similarly anaesthetized was prepared for recording B.P. from the carotid, respiration from the trachea, and for electrically stimulating the central end of a cut sciatic nerve.

Fig. 8 (*a*) shows the effect of 4 seconds stimulation of the central end of the cut sciatic nerve with a simple inductorium (coil distance 7 cm.) and that of the subsequent injection of 0·2 c.c. ethylene chlorohydrin. The rise in blood-pressure from afferent stimuli, the fall in B.P. as described above, and inhibition of respiration are all clearly seen.

Fig. 8 (*b*) shows the effect of afferent stimuli after the injection of the chlorohydrin when the blood-pressure had become re-established. It is seen that no effect upon the vascular reflex was produced and



a *b*

FIG. 8.—(*a*) Effect of 4 sec. stimulation of central end of cut sciatic of cat followed by intravenous injection of 0·2 c.c. ethylene chlorohydrin on B.P. (carotid) and respiration (trachea).

(*b*) follows (*a*) and shows that injection of chlorohydrin led to no demonstrable change on result of afferent stimulation. Inhibition of respiration by chlorohydrin is clearly seen.

the subsequent injection of 0·2 c.c. chlorohydrin produced an unaltered effect.

Similarly short stimuli to the left vagus trunk led to the characteristic cardiac inhibition with fall in blood-pressure and rapid recovery after cessation of the stimuli, a few minutes after the intravenous injection of 0·2 c.c. chlorohydrin.

Thus our experiment led us to conclude that:—

(1) Ethylene chlorohydrin (liquid) inhibits the heart.
(2) Ethylene chlorohydrin (liquid) inhibits respiration and in fatal doses brings about an asphyxial death.
(3) Ethylene chlorohydrin does not interfere with the response of the heart to vagal stimulation or with cardio-vascular reflexes from afferent stimulation.

In view of the probable direct action of chlorohydrin on the heart muscle, we tested the effect on the isolated perfused frog's heart.

6. Effect of Ethylene Chlorohydrin and Related Compounds on the Isolated Perfused Frog's Heart

The perfusion of the isolated heart was performed via the sinus using a Syme's cannula and continuously oxygenated Ringer-Locke solution. The arrangement was such that change from the normal perfusion fluid to fluid containing known concentrations of the test substances could be brought about in a few seconds. Fig. 9 shows typical results obtained. The effects may be summarized as follows:—

seems to be mainly on the cardiac muscle. It is to be noted that the concentrations required to produce a marked effect of even partial inhibition are high even for the dichloride and chlorohydrin, and that these compounds are readily washed out of the tissue.

Thus, it is not surprising that the effect of intravenous ethylene chlorohydrin on the blood-pressure of intact animals is transitory, lasting only as long as a high concentration remains in circulation. The fate of the chlorohydrin after removal from the circulation is not known.

7. Effect of Ethylene Chlorohydrin on Smooth Muscle Preparations

(a) Small Intestine of the Rabbit

The longitudinal muscle of the rabbit's jejunum was set up in the usual manner in 100 c.c. oxygenated Tyrode solution and measured amounts of ethylene chlorohydrin added to the bath.

From our observations on the isolated heart it might be expected that any marked effects on the intestinal preparations would be produced only by very considerable concentrations. This proved to be the case.

Fig. 10 shows (*a*) the effect of 10^{-2} (v/v) and (*b*) the effect of the same concentration after atropinization (atropine sulphate $0{\cdot}5\times10^{-4}$) of the same preparation. In all cases, after inhibition, change of the bath fluid was soon followed by re-establishment of rhythm and tone.

A rough comparison was made with the effects

TABLE 10

EFFECT OF ETHYLENE CHLOROHYDRIN AND RELATED COMPOUNDS ON THE FROG'S HEART

Compound	Molar concn.	Effect	Figure 9
Ethylene glycol	0·090	Practically none.	(*a*)
Ethyl alcohol	0·087	Marked slowing of the heart with diminution of systole. Complete recovery on changing back to normal perfusion fluid	(*b*), (*c*)
Ethylene chlorohydrin ..	0·074	Complete stoppage of heart in diastole. On changing back to Ringer-Locke a slowed rhythm followed by original rhythm re-established	(*d*)
Ethylene chlorohydrin ..	0·0074	Diminution of systole but no significant change in rhythm	(*f*) (upper tracing)
Ethylene dichloride.. ..	0·062	Similar to (*d*)	(*e*) The ethylene dichloride was present in the perfusate as extremely fine globules in suspension
Ethylene dichloride.. ..	0·0062	Similar to (*f*) upper tracing	(*f*) (lower tracing)

We are not concerned further to analyse these effects than to state that—

(1) the dichloride and the chlorohydrin are very much more depressant to the heart than ethyl alcohol;
(2) the heart is inhibited in diastole in all cases;
(3) ethylene glycol in the concentration used has no significant effect upon the isolated heart.

In addition, Fig. 9 (*f*) indicates that the action is not of the vagal type, since there was no slowing of the rhythm. The effects were exactly similar using the fully atropinized heart. The inhibitory effect of ethylene dichloride and ethyl alcohol on this preparation. From preliminary tests it became clear that for experiments of this kind with ethylene dichloride, it is essential to disperse the liquid. Exceedingly large doses can be added to the preparation without any effect but, if dispersed, immediate effects follow even very small doses. Table 11 shows effects of dispersed ethylene dichloride.

As to ethyl alcohol, a concentration of $0{\cdot}5\times10^{-2}$ leads to rapid increase in tone with no inhibition of rhythm.

Our results show that ethylene dichloride is a

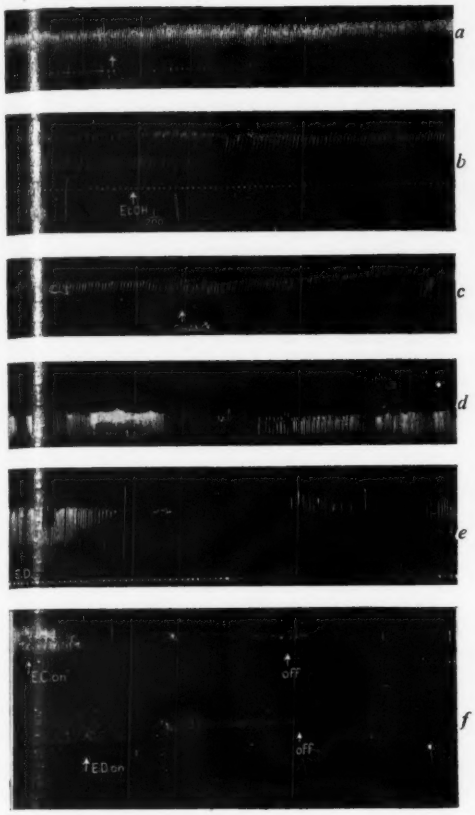


FIG. 9—Effects of ethylene glycol, ethyl alcohol, ethylene chlorohydrin, ethylene dichloride on isolated perfused heart of frog.
(*a*) Ethylene glycol 0·090 molar.
(*b*) Ethyl alcohol 0·087 molar.
(*c*) Recovery from (*b*) on change of bath.
(*d*) Ethylene chlorohydrin 0·074 molar showing recovery on changing bath.
(*e*) Fine suspension ethylene dichloride 0·062 molar, showing recovery on changing bath.
(*f*) Effect of 0·0074 molar ethylene chlorohydrin (upper tracing) and 0·0062 molar ethylene dichloride (lower tracing).
Time tracing—seconds.

TABLE 11

Concn. v/v.	Molar Concn.	Effect
10^{-2}	0·125	Immediate and irreversible inhibition
10^{-4}	0·000125	Apparent slight immediate increase of tone followed at once by inhibition of rhythm and complete relaxation. Completely reversible

much more powerful inhibitor of the gut than ethylene chlorohydrin, and the effect is independent of the vagal mechanism.

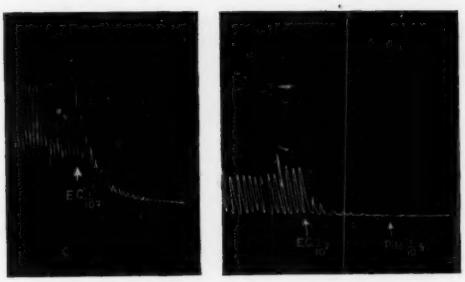


FIG. 10.—Effect of ethylene chlorohydrin on isolated rabbit intestinal muscle.

(b) Rat's Uterus

The inhibitory effect of ethylene chlorohydrin on smooth muscle is readily shown on the slow but fairly regular rhythm of the isolated rat's uterus (O_2-Tyrode). At a concentration of 0·07 molar the period of the regular contractions is slowed some 3 to 4 times: the individual contractions are not greatly diminished and there occurs some slight increase in tone.

It is a matter of considerable interest that such enormous concentrations of ethylene chlorohydrin should be required for these effects on isolated tissues. To speak of this compound as a protoplasmic poison (Koelsch) is, we feel, to be satisfied with a phrase. The ease with which complete recovery of normal activity is attained on merely washing the tissue is not what would be expected from a protoplasmic poison in any ordinary sense of the word.

This striking reversibility even after exposure to very high concentrations of ethylene chlorohydrin requires further elucidation.

8. Effect of Ethylene Chlorohydrin on the Transmission of Nerve Impulse

Clinical evidence indicates that ethylene chlorohydrin probably acts upon nervous tissue. Experimental support is readily obtainable by comparing the effects of electrical stimulation of the sciatic nerve of the frog before and during exposure of a small stretch of nerve to the compound. The ordinary sciatic-gastrocnemius preparation was used and stimulation of the nerve produced through the kymograph. The record of the muscle-twitch was made as usual on a fast-moving kymograph. The nerve-muscle preparation was set up on a paraffin surface with a small cup-like depression, in which fluid could be added or removed at will and in which a short length of the nerve lay between the muscle and the point of stimulation of the nerve. Throughout the experiment the preparation lay undisturbed and weak stimuli were applied at will. The contractions were isotonic.

Fig. 11 shows the effect of exposure of the small stretch of nerve to 1 per cent. ethylene chlorohydrin in Ringer-Lock solution. The lowest tracing shows the normal twitch. After 30 seconds of exposure the response to the same stimulus (coil distance 15 mm.) was already markedly diminished: after 150 seconds there was still further diminution of response, and after 7 minutes no response could be

FIG. 11.—Effect of ethylene chlorohydrin on transmission of nerve impulse in frog sciatic-gastrocnemius preparation—to be read from below up. 1 per cent. ethylene chlorohydrin used. Times given on tracing show periods of immersion until complete blockage of transmission and times after washing until almost complete recovery. Coil distance 15 mm.

obtained. At this point the ethylene chlorohydrin was removed and replaced by successive quantities of Ringer-Locke. Some 9 minutes after this washing process the same stimulus led to a considerable response and 14 minutes later an almost normal response was obtained. It will be observed that the time characters of the twitch are unchanged both during the period of suppression and of recovery of the response. There is thus demonstrated a block of a sufficient number of nerve fibres to prevent the particular stimulus used from producing an effective response of the muscle. This block effect is reversible by simple washing of the nerve with saline.

Similar experiments with 5 per cent. and undiluted chlorohydrin showed an intensification of the effects. But in all cases reversibility could be demonstrated by maintained washing of the nerve with Ringer-Locke solution.

At periods after washing when the initial stimulus was still ineffective, it could be shown that stronger stimuli produce considerable response. In all cases, however, return to a normal response to the initial stimulus was obtained.

Similar experiments were performed with mammalian nerves *in situ*, e.g. the peripheral end of the cat vagus using the blood-pressure and heart action as the effector organ, the central end of the cut vagus and respiration as the index, and the cervical sympathetic using the pupil as an index. Exactly similar results were obtained, in particular complete reversibility after complete block of a fixed stimulus.

The application of these results to the clinical picture of ethylene chlorohydrin poisoning goes no further, at this stage, than that the compound is capable of exerting a depressant action on nerve tissue and that some of the signs and symptoms may be related to this fact.

The order of magnitude of the nerve-blocking concentrations is not such as could be attained in circumstances of industrial exposure or even by injection into animals without causing rapid death. Nevertheless, it is conceivable that a property of this kind may have great significance when the compound is presented in even relatively very low concentration to the tracts in the brain or cord. The indubitable signs and symptoms of involvement of the nervous system in ethylene chlorohydrin poisoning must, it is suggested, be related to effects not dissimilar from those manifested in these nerve-block experiments.

9. Absorption of Ethylene Chlorohydrin through the Intact Skin

Animal experiments designed to show absorption of a toxic material through the skin should ideally be performed on animals the skins of which resemble in some degree that of man. The horse and the pig are probably the best from this point of view. When, however, one is restricted to the smaller laboratory animals, a good deal of precaution is necessary, both in experiment and in interpretation. Positive results in such experiments give only a qualitative indication. In general we take the view that if a compound is demonstrably absorbed through the skin of mice, rats, or guinea-pigs, then *a fortiori* it will be so absorbed by human skin. But if a negative result is obtained with these animals, it cannot be concluded that this applies also to man.

In the case of ethylene chlorohydrin, the evidence is unequivocal. Koelsch (*loc. cit.*) found it to be absorbed by guinea-pigs' skin. We have found it easy to demonstrate it in mice, but relatively large doses are required when we consider that about 1 mg. per 20 g. mouse is the M.L.D. if injected intraperitoneally.

The following results were obtained with 19 mice: doses varied from 0·03 c.c. to 0·09 c.c. undiluted chlorohydrin and only one dose was applied.

The conditions of diet, temperature, and manner of application to the dehaired area of skin were uniform. On applying the material it quickly spreads over the area and as far as one can make out, the major part of it cannot leave the skin: some will certainly be lost by evaporation. The fact that such enormous doses must be applied to produce death indicates that absorption must be slow enough to permit of excretion or detoxication, or both, of very considerable amounts of the compound.

TABLE 12

EFFECT OF ETHYLENE CHLOROHYDRIN APPLIED TO THE DEHAIRED SKIN OF MICE

No. of mice	Average weight	No. of drops	Size of drop	Calculated dose/20 g.	Deaths	Time of death
7	25 g.	1	0·03 c.c.	29 mg.	3/7	1 same day 2 next day
6	30 g.	2	0·03 c.c.	48 mg.	6/6	4 same day 2 next day
6	20 g.	3	0·03 c.c.	108 mg.	6/6	Same day (within 3 hours)

In applying these findings to man, all that can be said is that the compound can penetrate skin and that very large doses are required to endanger life. But this should suffice to insist on prevention of all skin contact with the liquid.

There was no evidence of direct skin irritation from the application of the compound.

Summary

1. The following concentrations of ethylene chlorohydrin vapour are lethal:

Rats .. 30 mins. at 0·004 g./lit. (1120 p.p.m. v/v)
Mice .. 60 mins. at 0·003 g./lit.
Guinea-pigs 112 mins. at 0·003 g./lit.

Pathological changes found after such acute exposures are: renal haemorrhages and tubular degeneration, collapse or rupture of pulmonary alveoli.

2. Repeated 15 minute exposures of rats to 0·003 g./lit. lead to death in from 3 to 11 days. Pathological changes were: renal haemorrhages and tubular necrosis, fatty degeneration and necrosis of liver, pulmonary haemorrhages and areas of collapse. In both acute and chronic exposures the renal glomeruli appeared normal.

3. The M.L.D. (rats: intraperitoneal: single injection) of ethylene chlorohydrin is between 5 and 6 mg. per 100 g. Injected repeatedly in doses much less than the M.L.D. very large amounts are tolerated (24 mg. in one group of 6 rats). M.L.D. (rats: by mouth: single dose) is between 7 and 8 mg. per 100 g.

4. Intravenous ethylene chlorohydrin in cats (chloralose) leads to fall in blood-pressure and inhibition of respiration. Vagal action and cardiovascular reflexes are not affected.

5. Ethylene chlorohydrin and ethylene dichloride are inhibitors of the perfused frog's heart. Ethyl alcohol is much less active in this respect and ethylene glycol is inactive in comparable concentrations. Inhibition is reversible in all cases.

6. Ethylene chlorohydrin inhibits both tone and rhythm of smooth muscle (small intestine, uterus): this effect is reversible.

7. Ethylene chlorohydrin (1 per cent.) in contact with nerve leads to complete nerve block. This effect is reversible.

8. Ethylene chlorohydrin is absorbed through the skin of mice and toxic effects follow.

Conclusions

1. Ethylene chlorohydrin is a powerful renal, hepatic, nerve, and vascular poison. It can be absorbed by inhalation, by the gut or through the skin. In respect of the lethal effects of the vapour on small animals, it appears to be more toxic than ethylene dichloride.

In relatively high concentrations it inhibits the heart, respiration, smooth muscle and nerve transmission: all these effects are reversible.

2. In the conditions of manufacture or use of ethylene chlorohydrin, the main hazard is probably inhalation of the vapour, but in certain operations repeated contamination of clothes and skin readily occurs unless adequate precautions are taken.

Such precautions will, in general, he difficult to take unless the toxic properties are adequately realized before the plant is installed.

3. Workers engaged in the manufacture or repeated use of ethylene chlorohydrin should be submitted to regular medical examination. It should be kept in mind that poisoning by this compound is subtle and that irreparable damage may have developed before marked clinical signs are manifest.

Signs and symptoms of cardio-vascular abnormalities of even minor degree, of renal disease, of disturbed hepatic function, of aberrations of nervous function and behaviour, and of gastro-intestinal function must all be sought and routine records kept.

Thanks are due to Miss Margaret Beech and Miss Kathleen Stott who assisted in the experimental work.

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MEAN INTELLIGENCE SCORES OF A RANDOM SAMPLE OF OCCUPATIONS

BY

H. T. HIMMELWEIT AND J. W. WHITFIELD

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A paper and pencil intelligence test * was given to Army recruits at training centres during the early part of the war. This report is based on the resultant scores of 10,000 individuals taken at random from all centres. Age and a description of civilian occupation were recorded for each individual in addition to test score.

The descriptions of civilian occupations were given sometimes in general and sometimes in specific terms. Classification was based on the exact description supplied by the individual—i.e. avoiding any grouping of nearly similar descriptions. There were 760 occupations, 39 of which were represented by 50 or more individuals each.

The mean value and standard deviation of test scores were calculated for each of the 39 main occupations (Table 1). Each occupation's mean score was compared with every other occupation's mean score, to see whether the difference between them indicates a real difference in the averages of intelligence in both occupations. (The significance of difference between means was determined by 'Student' 't' method, using P=0·05 as criterion of significance.)

The table shows the results obtained. Each occupation's mean score and standard deviation are given, and also the number of occupations whose mean scores are not significantly removed.

Fig. 1–8 show the test score distributions for certain occupations. In each figure the histogram shows the occupational distribution, expressed as the percentages falling into each test score interval. The continuous line is introduced for comparative purposes, and gives the distribution (also in percentages) of all 39 occupations.

Four points must be mentioned before considering the implications of the results.

(i) The recruits were asked to describe their civilian occupations as a routine matter on joining the Army. The accuracy of their statements was not checked.

(ii) No information was available as to the duration of their employment in the occupation.

(iii) No information was available as to their proficiency in the occupation.

(iv) The medically unfit, volunteers for other services, and those (in certain occupations) reserved as key men are not included.

Conclusions

There appears to be some evidence that intelligence operates as a selection factor in both high-grade and low-grade occupations. The highest grade occupations select to some extent by rejecting those with too low an intelligence, but the range of intelligence within any occupation is large. The middle range of occupations show much overlapping of intelligence levels, and include representatives of each intelligence level in approximately the same proportions as the general population. The lower grade occupations show slight selective effects, but it is noteworthy that several of the higher scoring labourers are better at the test than several of the lower scoring schoolmasters and teachers. It is impossible to say whether this is a form of labour wastage or whether there are other factors which make the higher scoring labourers unsuitable for higher grade work.

It would appear, therefore, that a wide range of intelligence is tolerated in most occupations. The highest grade occupations are exceptions to this to some degree. A person of average intelligence has a wide choice of occupations open to him as far as intelligence requirements are concerned. For vocational guidance or selection this means that, except at the extremes of the intelligence scale, factors other than intelligence must be considered in fitting individuals to their most suitable occupations.

The authors are indebted to the Industrial Health Research Board of the Medical Research Council for a grant for this investigation.

* The test was constructed to provide a rough measure of the mental level of Army recruits during the war. It is a paper and pencil group test, including synonyms, anonyms, number series, analogies, and inferences. The time allowed is ten minutes, and the maximum possible score is 60. The correlation with the Progressive Matrices Test is + 0·67.

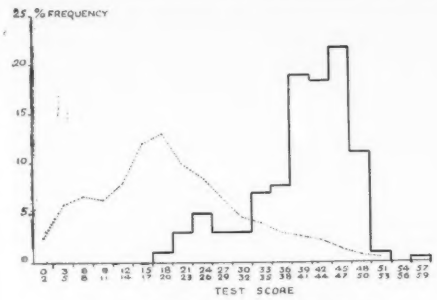

FIG. 1.—Schoolmasters and Teachers.

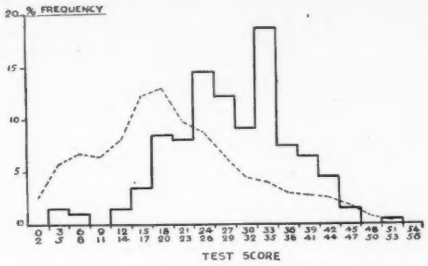

FIG. 2.—Clerks.

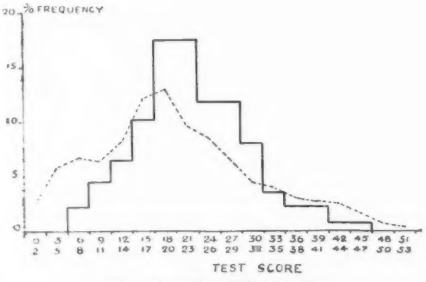

FIG. 3.—Shop Managers.

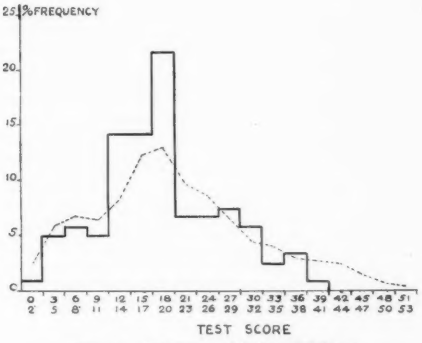

FIG. 4.—Fitters and Fitters' Mates.

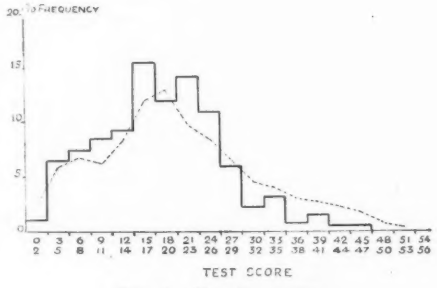

FIG. 5.—Warehousemen.

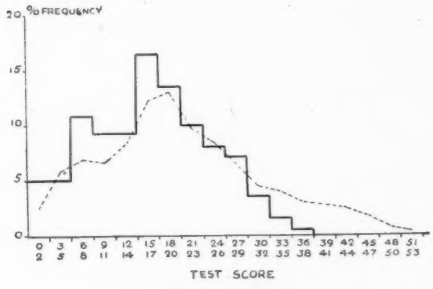

FIG. 6.—Gardeners.

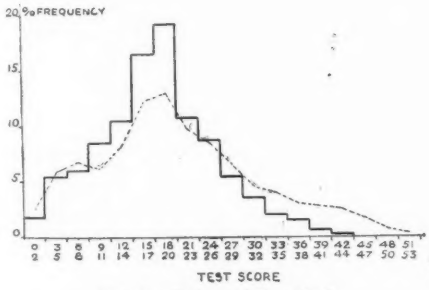

FIG. 7.—Drivers (all grades).

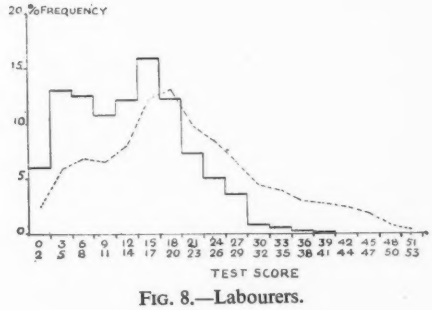

FIG. 8.—Labourers.

TABLE 1

TEST SCORES OF THIRTY-NINE OCCUPATIONS

Occupation	No. tested	Mean test score	Standard deviation	No. of occupations with higher mean not significantly different	No. of occupations with lower mean not significantly different
Schoolmaster	92	40·65	7·46	0	1
Teacher	109	39·68	7·22	1	0
Student	237	37·66	7·72	0	0
Bank Clerk	104	34·97	7·83	0	0
Railway Clerk	180	31·79	7·72	0	0
Clerk	197	28·93	9·77	0	1
Messenger	54	25·80	7·75	0	2
Electrician	50	25·78	10·13	2	3
Baker	63	23·30	7·22	2	3
Shop Assistant	118	22·76	8·89	2	4
Shop Manager	136	22·76	7·65	3	3
Grocer	57	21·51	8·15	3	16
Fitter	70	20·48	8·24	3	14
Wood Machinist	110	20·33	7·80	2	10
Shoe Operative	52	20·33	7·75	5	13
Bus Conductor	99	20·15	7·75	4	11
Postman	61	19·21	9·62	5	16
Mechanic	56	19·16	7·84	6	13
Fitter's Mate	50	19·05	8·94	7	16
Van Driver	112	18·88	7·81	8	10
Carpenter	60	18·88	8·94	9	14
Salesman	63	18·78	8·62	10	13
Storekeeper	70	18·45	8·25	11	12
Motor Driver	229	18·31	7·88	11	8
Roundsman	119	18·18	7·59	12	10
Warehouseman	219	18·16	8·64	11	8
Builder's Lab.	58	17·98	7·64	15	8
Lorry Driver	416	17·94	7·56	11	6
Butcher	64	17·73	8·02	16	8
Driver's Mate	79	16·73	8·63	13	7
Painter	98	16·38	8·46	12	6
Driver	133	16·32	8·49	12	5
Porter	68	16·31	8·64	15	4
Gardener	139	16·25	8·19	11	3
Railway Porter	59	15·76	8·31	14	2
Miner	60	14·90	8·31	7	3
Cleaner	50	14·68	8·67	8	2
Labourer	1113	13·40	7·80	2	1
Carter	50	12·04	8·56	3	0

TOXIC POLYNEURITIS ARISING DURING THE MANUFACTURE OF TRICRESYL PHOSPHATE

BY

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This communication records the toxic effects caused by tri-*ortho*-cresyl phosphate in three men employed in its manufacture. Tricresyl phosphate is used in the recovery of phenol residues from gas plant effluents and also as a plasticizer in the plastics industry. A plasticizer is a substance used to render a plastic material more pliable, and by alteration of the amount of the plasticizer added, such characteristics as flexibility, hardness, water resistance and inflammability can be varied between wide limits. In this industry it is being used in increasing quantities, for example, as much as 50 per cent. of tricresyl phosphate is sometimes added to polyvinyl chloride. Tricresyl phosphate used in industry is an oil with a slightly pungent odour: of the three isomerides the *ortho-* and *meta-* are liquids, and the *para-* is a crystalline solid. Industrial tricresyl phosphate is prepared by treating cresols with phosphorus oxychloride in the presence of an aluminium catalyst. It has been the boast of industry in the United States of America that in a plant manufacturing 100,000 lb. of this material a day without any special precautions no cases of poisoning have occurred. However, since 1939 black-out regulations in Great Britain, imposed as a precaution against air attack, have led to a less fortunate state of affairs, and three workmen employed in a manufacturing plant have developed polyneuritis. As a result of these cases poisoning by tricresyl and triphenyl phosphate resulting from the manufacture or use of these products in industry was scheduled under the Workmen's Compensation (Industrial Diseases) Order, 1942, No. 1326.

Environmental Conditions

All three of these men worked in a room about 25 feet long, 12 feet wide, and 12 feet high which, owing to black-out regulations, was totally enclosed during the hours of darkness, although it was provided with a roof vent. During daylight doors and windows were open. The men worked at wash tanks which were roughly cubic vessels of about 5 feet high, with a partially open top. The closed-in portion of the top supported the various fittings, one of these being a 6 inch vent pipe extending through the roof to the open air. Crude tricresyl phosphate entered these tanks at a temperature of approximately 60° C. At this stage it contained hydrochloric acid which gave it an unpleasant irritating odour. However, it was immediately cooled by treatment with an equal volume of cold water, this operation being carried out by opening a valve and shutting it at the appropriate moment. The washing was automatic, but it was nevertheless possible for the men to inhale vapour from the tanks. The cold tricresyl phosphate is of low volatility, having a low vapour pressure at ordinary temperature. The *ortho*-isomer content of the finished product was about 60 per cent. The three affected men also handled triphenyl phosphate.

It was not possible at the time the men were poisoned to determine the concentration of tricresyl phosphate which was present in the atmosphere. This, however, was estimated at a later date when conditions were arranged to reproduce those in operation at the time. The injectors, fans and air conditioning plant were shut off, the covers of the washing vats left open, and the water drained from the cooler. The determinations were carried out during daytime, and also during simulated and actual black-out conditions. The highest concentration of tricresyl phosphate was found in the room containing the washing vats after the hot liquid had been blown over from the reaction vessels into the washing vats. Twenty litres of atmosphere were aspirated through an absorption train for 16 to 30 minutes, commencing 5–10 minutes before the end of the delivery of hot liquid. The absorption train consisted of 2 bubblers, each containing 100 mls. of alcohol, followed by 2 tubes packed with glass wool and cotton wool respectively. Over 90 per cent. of the tricresyl phosphate was found in the first bubbler, the remainder in the second, and none in the wools. The tricresyl phosphate was determined by estimating colorimetrically the P_2O_5 produced by its decomposition.

TABLE 1

SAMPLES OF ATMOSPHERE FROM A POINT INSIDE THE WASHING VAT 6–9 INCHES ABOVE THE FINAL LEVEL OF THE LIQUID.

	Daytime		
Tricresyl phosphate	A	B	C
Mgs. per 20 litres	0·2	0·2	0·1
Mgs. per cu.m.	10	10	5
Parts per million wt/wt. ..	8	8	4
Parts per million vol/vol.	0·6	0·6	0·3

TABLE 2

SAMPLES OF ATMOSPHERE FROM A POINT 9 INCHES ABOVE THE TOP OF THE WASHING VAT AND OVER THE CENTRE OF THE OPENING.

Tricresyl phosphate	Simulated black-out	Actual black-out
Mgs. per 20 litres ..	<0·05	<0·05
Mgs. per cu.m.	<2·5	<2·5
Parts per million wt/wt. ..	<2	<2
Parts per million vol/vol.	<0·15	<0·15

TABLE 3

SAMPLES OF ATMOSPHERE FROM A POINT AT SHOULDER HEIGHT FROM THE FLOOR AND 2 FEET IN FRONT OF THE WASHING VAT.

Tricresyl Phosphate	Simulated black-out	Actual black-out
Mgs. per 20 litres ..	<0·02	<0·02
Mgs. per cu.m.	<1·0	<1·0
Parts per million wt/wt. ..	<1·0	<1·0
Parts per million vol/vol.	<0·06	<0·06

Finally, samples of the atmosphere in one of the rooms containing washing vats were taken over a period of 24 hours on three occasions. In these experiments the alcohol in the bubblers was replaced by 20 mls. of ethylene glycol monomethyl ether in the first and 25 mls. of water in the second. These samples were drawn from a point 4 feet 9 inches above the lower step, 3 inches in front of the washer and 3 inches along the opening from the right-hand end. Black-out conditions were in operation during black-out times in the month of April.

TABLE 4

	A	B	C
Volume of atmosphere tested	16 cu. ft.	30 cu. ft.	26 cu. ft.
Tricresyl phosphate			
Mgs. in volume under test	0·75	0·47	0·67
Mgs. per cu.m.	1·66	0·55	0·91
Parts per million wt/wt. ..	1·28	0·42	0·70
Parts per million vol/vol.	0·10	0·03	0·06

The method of estimating the tricresyl phosphate was as follows:—1 ml. of a dilute solution of tricresyl phosphate (0·1 mg.) in alcohol was transferred to a platinum dish with 25 mls. of alcohol and 2 mls. of N/10 KOH solution. The dish was placed on a water bath and heated until dry. The dish was then gently heated, using a low flame until charring finished, and then more strongly to remove the bulk of the carbon. The dish and contents were allowed to cool and 5 mls. of water and 2 drops of nitric acid were added and mixed. At this stage the solution was definitely acid. The dish was transferred to a water bath and the solution evaporated to dryness. The residue was dissolved in a little water and transferred to a test tube (6 in. × 1 in.). 1 ml. of 0·01 per cent. $Na_2HPO_4 12H_2O$ ($P_2O_5 \equiv 0{\cdot}1$ mg. tricresyl phosphate), 2 mls. of N/10 KOH and 2 drops of nitric acid were placed in a control tube. The level of liquids in both tubes were adjusted to the same height and to both tubes were added, with shaking, 0·5 mls. of molybdate reagent (5 gms. of ammonium molybdate dissolved in 100 mls. of cold water and poured into 35 mls. of nitric acid (d=1·2)) followed by 0·5 mls. of benzidine reagent (0·05 gms. of benzidine hydrochloride dissolved in 10 mls. of glacial acetic acid and diluted with water to 100 mls.). Ammonia was then added to both tubes approximately simultaneously to develop alkalinity and the blue colour. Both solutions gave colours of the same intensity and the results can be regarded as quantitative.

It is important that contact with any glass, including stirring rods, be avoided when the solutions are hot and alkaline as traces of silica are absorbed and nullify the results.

Case Histories

Case 1. E.R., a man aged 41 years. For three years before admission to hospital the patient had been employed in a chemical factory, at first working on nitrating processes. Six months later he began to handle cresol, phenol, phosphorous oxychloride, caustic soda and sulphuric acid making tri-*ortho*-cresyl phosphate and triphenyl phosphate. For six months before admission the process was speeded up for Government contract and the plant production rose by 30 per cent. He worked every Sunday instead of one in four. Two weeks before he was seen he complained of slight stiffness of the neck. For two days before he had had lower abdominal pain accompanied by diarrhoea, passing three pale watery stools per day. Five days later he suddenly found he could not walk properly. He was unable to lift his toes and his feet dragged. The disability progressed until eventually he was unable to stand without the help of a stick. He then found that he had weakness of the fingers of both hands and he was unable to do up buttons. There were occasional tingling sensations and numbness in the calves of both legs. *Previous history.*—Bronchitis during the last year. *Family history.*—Father and mother dead. Three brothers and two sisters alive and well. There was no familial nervous disease. *Condition on admission.*—Robust man. Afebrile. No abnormality in respiratory, cardiovascular or gastro-intestinal systems. Nervous system: no mental abnormality; no abnormality detected in cranial nerves; fundi normal. Upper limbs: weakness of hand grip and of dorsi-flexion of both wrists: slight symmetrical wasting of thenar, hypothenar and first dorsal interosseous muscles. Reflexes all present and equal. No sensory loss. Lower limbs: great weakness of dorsiflexors and plantar flexors of ankles; slight symmetrical wasting of calves; flail ankle joints; knee jerks brisk and equal; ankle jerks absent; plantar responses flexor. Slow, high-stepping, rather stamping gait. Two-point discrimination normal; appreciation of pin-prick, cotton wool touch, vibration and posture normal. *Special examinations.*—Blood count: Haemoglobin (Sahli) 92 per cent., white cells 8200 per cmm., differential count normal; no abnormality seen in stained film. Blood Wassermann reaction negative. Lumbar puncture: pressure 95 mm. of cerebro-spinal fluid; Queckenstedt's test normal; fluid clear and colourless; no excess of white cells; protein 18 mg. per 100 cc., Wassermann reaction negative. Fractional test meal: no free hydrochloric acid for 2½ hours, later rose to 0·08 per cent. Urine: no albumin or sugar. *Progress.*—He was treated with vitamin E by mouth and vitamin B intra-muscularly. His muscles were treated first by rest and then with massage and galvanism. After the third week he began to show slow but steady improvement and six months after admission he was discharged. He then walked with a high-steppage gait. Uplifting toe springs fitted to his boots helped him. One year after admission he had completely recovered and was able to return to work.

Case 2. G.M., a man aged 30 years (L.H. Reg. No. M.168/1941). For 8 months previous to admission the patient had been employed in the manufacture of tricresyl phosphate and was in contact with the same substances as case 1. He worked for 63 hours per week. Five months later he began to complain of cramp-like pains in the thighs, calf muscles and toes. About the same time he noticed that he had recurrent attacks of hiccup. One month before admission he had an attack of diarrhoea, unaccompanied by abdominal pain or vomiting, which lasted one day, and soon afterwards he noticed that his feet were weak and found that he had to lift up his legs to prevent his toes dragging along the ground. He found that he could only walk with difficulty and consequently took to bicycling. More recently he complained of ' fluttering ' of various muscles all over his body, chiefly forearms, neck and thighs. *Previous history.*—He had scarlet fever with acute nephritis as a child. At the age of 15 he was employed in the production of lead arsenate and had several attacks of abdominal colic. Five years before admission he developed a secondary anaemia which responded well to iron. *Family history.*—Father died of pneumonia at the age of 50. Mother and one brother and four sisters alive and well. There was no familial nervous disease. *Condition on admission.*—Intelligent, slightly pale man. Weight 10 st. 5 lb. Afebrile. Yellow stain on hands

and particularly around finger nails. Caustic soda ulcer on one finger. Cold, moist hands and feet. No abnormality discovered in the respiratory, cardiovascular or gastro-intestinal systems. Nervous system: no mental abnormality; concomitant strabismus; congenital nystagmus; fundi and pupils normal. Upper limbs: weakness of flexors and extensors of wrists and fingers, of dorsal and palmar interossei and lumbricals; wasting of thenar and hypothenar eminences and of first dorsal interosseous muscle, some hypotonus of muscles of the wrists; reflexes all present and equal; no sensory loss. Abdominal reflexes present and equal. Lower limbs: gross weakness of dorsi-flexors and plantar flexors of both feet; he was unable to move his toes; wasting and hypotonus of both calves, the left is half an inch smaller than the right; wasting and hypotonus of tibialis anticus on both sides; flail ankle joints; sensation unimpaired; calves and tendo-Achilles very tender on pressure; fibrillation of muscles of thighs and forearms; knee jerks exaggerated; ankle jerks absent; plantar responses flexor. Slow, high-stepping gait with dragging of feet. *Special examinations.*—Blood count: red cells 4,500,000 per cmm., haemoglobin (Sahli) 88 per cent., colour index 0·9, white cells 13,400 per cmm., differential count normal; no abnormality seen in stained films. Blood Wassermann reaction negative. Lumbar puncture: pressure 100 mm. of cerebro-spinal fluid; Queckenstedt's test normal; fluid clear and colourless; no excess of white cells; protein 20 mg. per 100 cc., Wassermann reaction negative. Urine: no albumin or sugar. *Progress.*—For six weeks after admission the weakness of the feet became worse. After three months, however, there were signs of improvement, the patient being able to move some of his toes. The flexors and extensors of the wrists were improved. Fibrillary tremors of thighs were particularly marked. Plantar responses unobtainable. He was treated with vitamin B_1 intra muscularly and with massage and movements. He continued to make progress and regained power in the upper limbs which returned to normal. There was great improvement in dorsi-flexion and plantar flexion of the foot, and he was discharged from hospital after 19 months, wearing uplifting toe springs. He continued to make slow progress and after $3\frac{1}{2}$ years there were only slight residual signs, and he returned to work.

Case 3. G.S., a man aged 38 years. (L.H. Reg. No. M.252/1941). For six months before admission the patient had been employed in the manufacture of tri-*ortho*-cresyl phosphate, and he did exactly the same job as the other two men. During this time he had complained of cramp-like pains in the hands which came on after he had been lifting heavy drums. Ten days before admission he had diarrhoea, passing 5 stools per day for 2 days unaccompanied by abdominal pain, and 1 day later he noticed that his toes dragged along the ground and that his feet slapped down as he walked. At the same time there was a severe aching pain in his calf muscles, particularly on standing or walking, and at intervals severe stabbing, shooting pains in the same group of muscles. He also had severe pains in his hands radiating upwards into the forearms and he found he was unable to extend his fingers which became fixed in a position of semi-flexion. As this pain gradually wore off so also was he able to straighten his fingers. The weakness of his legs gradually became worse. *Previous history.*—At the age of 33 he was admitted to hospital with a history of having drunk spirits of salts. *Family history.*—Wife died by suicide. Three children alive and well. Two brothers and one sister alive and well. There was no familial nervous disease. *Condition on admission.*—Well nourished man. Afebrile. Quantities of yellow material around nail beds. No abnormality in cardiovascular, respiratory or gastro-intestinal systems. Harrison's sulcus. Scoliosis. Nervous system: no mental abnormality; no abnormality in cranial nerves; fundi normal. Upper limbs: slight weakness of extension of wrists, especially left; no wasting or alteration in tone; reflexes all present and equal; no sensory loss. Abdominal reflexes present and equal Lower limbs: weakness of dorsi-flexors and less of plantar flexors of feet; slight wasting of calf muscles, more of tibialis anticus; general slight flaccidity of plantar and dorsi-flexors of feet; fibrillary tremors of thigh muscles; no impairment of sensation; marked tenderness of calves and tendo-Achilles; knee jerks present and equal; absent ankle jerks; plantar responses flexor. Gait slow and high-stepping. *Special examinations.*—Blood count: red cells 4,700,000 per c.mm., haemoglobin (Sahli) 92 per cent., colour index 0·9, white cells 8000 per c.mm., differential count normal; no abnormality seen in stained films. Blood Wassermann reaction negative. Lumbar puncture: pressure 100 mm. of cerebro-spinal fluid; Queckenstedt's test normal; fluid clear and colourless; no excess of white cells; protein 100 mg. per 100 cc.; Wassermann reaction negative. Urine: no albumin or sugar. *Progress.*—He was treated with vitamin B_1 intramuscularly and with massage and movements. He made steady progress and the power in the legs returned with increased ability to dorsi-flex his feet. Movement returned in both big toes after four months, but fibrillary tremors of thigh muscles persisted. He was discharged after ten months in hospital, able to walk with no evidence of foot-drop, and he returned to work.

The clinical picture of tri-*ortho*-cresyl phosphate poisoning is that of a polyneuritis with flaccid paralysis of the distal muscles of the upper and lower extremities. Slow but complete recovery usually occurs. These three cases were of men engaged in the manufacture of tricresyl phosphate. Up to the present time no case has been reported in men using the substance as a plasticiser or in those moulding plastics. As is shown later, however, plastic materials containing tricresyl phosphate have given rise to symptoms in experimental animals.

Opportunities to study this clinical picture occurred during a period of 40 years prior to the discovery of the first victim of industrial poisoning. It was encountered in patients treated for pulmonary tuberculosis with phospho-creosote, in people who had partaken of an alcoholic beverage known as *Jamaica ginger* or *jake*, in women who had taken apiol as an abortifacient, and in certain victims fed on a soya bean cooking oil adulterated by accident.

Previous Outbreaks of Poisoning with Tricresyl Phosphate

In 1899 Lorot reported six cases of multiple neuritis out of 41 cases of pulmonary tuberculosis treated with phospho-creosote. This substance was discovered in 1894. Later it was shown to contain 15 per cent. of tri-*ortho*-cresyl phosphate. In the next 35 years 53 additional cases were recorded in various parts of Continental Europe (Roger and Recordier, 1934).

In the spring of 1930 there appeared suddenly, in the mid-western and south-western states of the United States of America, an outbreak of paralysis characterized by bilateral foot- and wrist-drop. During March and April of that year almost 4,000 cases were reported in the press throughout the United States of America. During the whole year 15,000 people were affected, and of these 10 died. A connexion was immediately recognized between this paralysis and the ingestion of adulterated samples of the popular alcoholic drink already mentioned—*Jamaica ginger* or *jake*. The quantity of ginger fluid consumed was not the determining factor in the severity of the symptoms which followed; a single drink is known to have produced

the same result as that following the use of the beverage for many days.

The clinical picture develops by three stages. In some cases there are early transient gastro-intestinal symptoms including nausea, vomiting, diarrhoea, and abdominal pain. These clear up and a symptom-free interval follows lasting from 5 to 21 days, the average being 10 days. This interval is followed by soreness of the muscles below the knees and numbness of the toes and fingers lasting several days and followed by weakness of the toes and bilateral foot-drop. After another interval of about 10 days weakness of the fingers and wrist-drop follows. This paralysis is not usually as severe as that in the feet and legs. In the upper extremities paralysis does not extend above the elbows. The thigh muscles may be involved in advanced cases. There are neither sensory changes nor loss of sphincter control.

By July, 1930, Smith and Elvove proved that the adulterated beverage contained about two per cent. of tri-*ortho*-cresyl phosphate and that this caused the paralysis. The reason for including this substance as one of the ingredients will probably never be known. It may have been used on account of its physical properties. By subcutaneous injection of samples of the adulterated drink, as well as of pure synthetic tri-*ortho*-cresyl phosphate, Smith and Elvove succeeded in producing a paralysis comparable to that seen in human beings in a variety of laboratory animals including hens, rabbits, calves, dogs and monkeys.

Zeligs (1938) had the opportunity to follow up 316 cases of *jake* paralysis during 6 years. His description of the clinical picture in 1930 and later in 1936 shows that the poison may attack the anterior horn cells and the pyramidal tracts, in addition to the peripheral motor nerves. In 1930 all the patients had typical foot-drop, the degree of paralysis varying from slight muscular weakness to complete flaccid paralysis of all the muscles of the feet and legs. In about three-fourths of the cases the upper extremities became similarly involved, wrist-drop being common. The ankle jerks were absent, the knee jerks present and in many cases over-active. There were no abnormal plantar responses and no ankle clonus. Sensory changes were absent. During the next six years many of the patients recovered completely and others improved sufficiently to be able to use their hands and feet adequately. Out of 316 patients admitted to the Cincinnati General Hospital in 1930 a group of 60 were found still in institutions in 1936. They hobbled about with the aid of sticks. Physical examination showed spastic paralysis with adductor spasm, paralytic talipes, exaggerated tendon reflexes, and extensor plantar responses. In the upper extremities there was marked atrophy of the extensors of the wrists and of the interossei, with bilateral claw hands.

The initial conception of tri-*ortho*-cresyl phosphate poisoning as being a peripheral neuritis is therefore no longer tenable. The anterior horn cells and pyramidal tracts may sometimes be affected too, but the extreme muscular wasting tends to mask the involvement of the upper motor neurone. When muscular activity is partially restored the spastic signs of the previously hidden upper motor neurone lesion become clinically apparent. In such cases the end result resembles amyotrophic lateral sclerosis.

In 1931 ter Braak reported in Holland an outbreak of some 40 cases of paralysis from the use of apiol as an abortifacient. During 1931 and 1932 50 more cases were published from Germany, France, Switzerland, and Jugoslavia. Samples of apiol were found to be adulterated with tri-*ortho*-cresyl phosphate to the extent of 28 to 50 per cent. (Germon, 1932). Nobody knows why this substance was chosen as an adulterant. Neither in colour, taste, nor odour do the two oils resemble each other. In the women affected there was a lower motor neurone paralysis of the distal muscles of the extremities, without sensory loss.

In April, 1937, there occurred an outbreak affecting 68 people who had partaken of soya bean oil used for salads and for cooking. Forty-one of these people lived in Natal and the other 27 travelled in a ship which had been provisioned in Durban (Sampson, 1938, 1942). This oil was found to contain 0·4 per cent. of tri-*ortho*-cresyl phosphate. The victims first had gastro-intestinal symptoms and 7 to 14 days later developed cramps in the calves of their legs. Ultimately lower motor neurone paralysis of the feet and hands supervened, but sensation was unimpaired.

Cases of tri-*ortho*-cresyl phosphate poisoning have recently occurred in Münster owing to shortage of fats in Germany. The patients were factory workers who had obtained a fat substitute from their place of work. They had taken it home and, because of the shortage of natural animal and vegetable fats, had used it to fry potato pancakes. They developed nausea, vomiting, abdominal cramps, and diarrhoea, followed in 10 days by rapidly increasing weakness of the feet, legs, and then arms. There was progressive atrophy of the muscles. As a result of this outbreak, a warning was issued to factory medical officers in Germany, who were instructed to prevent recurrences by education and propaganda (Humpe, 1942).

Portal of Entry

Hamilton (1934) suggested that dangerous exposure to tri-*ortho*-cresyl phosphate might occur in the mixing of lacquers containing this material as a plasticizer, particularly if the ingredients were heated.

Hodge and Sterner (1943) estimated the amount of tri-*ortho*-cresyl phosphate that can be absorbed through unbroken skin, and how rapidly the absorption occurs. Tri-*ortho*-cresyl phosphate containing radio-active phosphorus was used and the absorption measured in two human subjects and one dog. The human subjects applied 0·22 g. and 0·11 g. of the tri-*ortho*-cresyl phosphate with radio-activity of 395,000 counts/mm./0·1 g. The first had thirteen micrograms of tri-*ortho*-cresyl phosphate per 100 cc. of blood at the end of one hour, and he excreted seven micrograms in the urine in the first hour, and continued at 35 micrograms an hour for the next 24 hours. He excreted 797 micrograms or 0·36 per cent. of the amount applied. The second had four micrograms per 100 cc. of blood at the end of one hour, and excreted 143 micrograms or 0·13 per cent. of the amount applied.

2·094 g. of the tri-*ortho*-cresyl phosphate was applied to the abdomen of a bitch and the blood level quickly established itself at 8 micrograms/100 cc., and maintained this for 24 hours. The urinary excretion began equally promptly, being

44 micrograms in the first hour, rising after seven hours to a maximum of 1312 micrograms. The radio-active phosphate was distributed in the various tissues of the dog 24 hours after its application to the abdominal surface. Retention was in the following order:—visceral organs, muscle, brain, bone.

The authors consider that the magnitude of absorption of tri-*ortho*-cresyl phosphate through human skin is such that a real hazard exists in industrial operations permitting a considerable or repeated exposure to this compound. A safe industrial hygiene control requires that measures be taken to prevent such skin contact, and that all workmen exposed to the compound be instructed as to the hazard, and the necessity for preventing skin contamination.

Because of the low volatility of tri-*ortho*-cresyl phosphate and the low vapour pressure at ordinary temperature, it has been argued that poisoning cannot occur from inhalation. However, the fact that in our cases the symptoms were precipitated by the introduction of black-out conditions suggested that poisoning may arise in this way. Further, in order to try to prevent recurrence, the firm employing the men fitted the wash tank room with ventilators and a fan. The tanks were closed in and the vents fitted with injectors, so that the vapours might be quickly transferred to the open air. Since these precautions no further cases of poisoning have occurred, and it is therefore possible that the lungs were the portal of entry of the poison in our cases. However, the black-out conditions in the plant raised the temperature: and the introduction of a more elaborate ventilating system substantially lowered this temperature. In view of the atmosphere concentrations a more probable explanation is that increased sweating caused greater absorption through the skin.

Experimental Evidence of Toxicity

Smith and Elvove (1930) showed that the specific toxicity of tri-*ortho*-cresyl phosphate for the motor nerves is not shared by the *meta* or *para* cresyl esters or by the phenyl ester. The dosage of tri-*ortho* cresyl phosphate was approximately 30 times less than that of triphenyl phosphate. Flinn (1943) was able to produce paralysis in 28 days in domestic fowls fed with cellophane, containing 11 per cent. of tri-*ortho*-cresyl phosphate, in amounts of 1 gm. per kilo of body weight.

Attempts were made to confirm these experimental observations. Twelve twelve-week old hens were obtained and fed with gelatin coated capsules containing 0·5 g. of one of the pure isomers of tricresyl phosphate or triphenyl phosphate. Four hens were used as controls, and two each were fed with tri-*meta*, tri-*para*, and tri-*ortho*-cresyl phosphate and triphenyl phosphate. Unfortunately two of the controls developed fowl paralysis after the others had had 2 g. of the drug. It was noticed, however, that the two hens which received the tri-*ortho*-cresyl phosphate became completely paralysed in the wings and legs. The fowl paralysis in the controls rendered this experiment unsatisfactory, and it was therefore repeated with 12 twelve-week old cockerels. After receiving 3 g. of tri-*ortho*-cresyl phosphate two cockerels became paralysed and died four days after receiving 3·5 g. After 12·5 g. the two cockerels fed with tri-*meta*-cresyl phosphate showed considerable weakness of the legs, and after 15·5 g. they developed respiratory paralysis. They were grossly emaciated and were then killed. The cockerels which were fed with tri-*para*-cresyl phosphate and triphenyl phosphate showed no evidence of ill-health after they had received 25 g.

Measures for Prevention of Poisoning

Since there is experimental evidence that tri-*ortho*-cresyl phosphate can be absorbed through the skin, it is important, as a measure of prevention, that workers with these compounds should wear elbow length gloves to protect their hands and arms, and should change into special clothing during their working hours. This will prevent the possibility of smoking and food being eaten and thus contaminated with dirty hands. Bathing facilities for use at the end of the work period are also desirable. In the cases described in this paper the portal of entry may have been the respiratory tract, and therefore all rooms where the substances are used should be provided with exhaust ventilation. Tanks should be closed in and the vents fitted with ejectors so that the vapours may be quickly transferred to the open air.

Summary

The literature of the toxicity of tricresyl and triphenyl phosphate is reviewed. An account is given of the cases of three men who developed a toxic polyneuritis while working in industry in the manufacture of tricresyl phosphate. Experiments on domestic fowls confirm that tri-*ortho*-cresyl phosphate is toxic. 3·5 g. of tri-*ortho*-cresyl phosphate killed two twelve-week old cockerels. 12·5 g. of tri-*meta*-cresyl phosphate produced weakness of the legs, and 15·5 g. respiratory paralysis, whereas 25 g. of tri-*para*-cresyl phosphate and triphenyl phosphate produced no effect. Measures for the prevention of poisoning are discussed.

We are much indebted to Mr. R. Milton and Dr. J. Graham for help with the animal experiments, and to the research chemists of Messrs. A. Boake, Roberts & Co., Ltd., for preparing the isomers of tricresyl phosphate in pure form for these experiments.

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ANCILLARY HEALTH SERVICES IN INDUSTRY *

BY

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The wisdom of providing medical services in industry is now generally recognized. The service may be regarded as being largely preventive and educational. The ancillary services with which this paper deals are subordinate to such a medical service, and differ from it in that they exist to provide individual treatment. There is this further difference that while there can be no substitute for an industrial medical service the treatment provided under the ancillary schemes can, for the most part, be obtained elsewhere; however, it is often not readily available, and for this reason is often neglected. The provision of these facilities in industry represents an attempt to overcome this difficulty. Even though it be admitted that existing provisions for treatment of dental, eye and foot conditions is inadequate, the case for asking industry to provide this treatment directly for its workpeople is not a good one; such treatment should, ideally, be readily available to all, and should, moreover, be used by every person who is in need of it. This is obviously envisaged in the recent white paper on a national health service. It is there admitted, however, that it will not be a practical proposition for a number of years. But we have in this country a long tradition of independent action by far-sighted individuals, resulting in advances upon which have been built at a later date schemes of nation-wide application. It is not unreasonable, therefore, to expect certain progressive employers to provide these services. In fact, even before the outbreak of war, services of this type were not infrequently provided in industry.

In discussing any ancillary health service two vitally interested parties must be considered: the employer, who has to organize it and in part to pay for it, and the employee who is to use it. The employer may wish to justify his action on economic grounds, and though this may not be easy it should be possible in many cases. Other employers are less concerned with the economic aspect in its narrower interpretation, and are prompted by their sense of social responsibility to do all in their power to promote the health of their employees. The employee, on his part, demands that any services set up are efficient and scientifically sound.

Rules for Planning

There are a few simple and fundamental rules which should guide the planning of the three main ancillary health services—foot, eye and dental clinics—and it is the purpose of this paper to indicate briefly the lines along which such departments may be organized.

(1) No scheme will succeed unless it has the support of the employees concerned. It is more important that the worker should retain his sense of independence and freedom than that he should have his corns or his teeth treated—though it is recognized that the comfort this treatment will bring may help to achieve an equanimity otherwise impossible. The service, therefore, must be optional.

(2) The next essential is that the treatment provided should be of a high order. Well qualified men and women should be employed, and adequate equipment must be provided. Those appointed should be temperamentally suited to the work so that they will inspire confidence, and they must also be fully alive to the educational opportunities afforded them.

(3) The service should not be provided free, but should be paid for, at least in part, by the workman. He should, however, be able to receive treatment in the employer's time, and should, if necessary, be allowed to pay for it by weekly deductions from wages, extending over a reasonable period. The services are thus made easily available and are officially encouraged by the firm.

Ancillary Services in 42 Firms

Information regarding the nature of the different services, and how they are best provided, is based on answers to a questionary sent by the writer to 42 firms of varying size. In these firms three main services are in operation, foot, eye and dental; one firm has an ante-natal clinic;† and 31 of the firms use one or other form of physiotherapy—itself not a true ancillary service, but an essential adjunct to any factory clinic.‡

* A post-graduate lecture given at Manchester University.

† Ante-natal services have no place in industry in peace-time. In war-time, however, it is a convenience both to mother and to employer to have an ante-natal clinic readily accessible at the place of work; ante-natal advice is more likely to be sought, and considerable working time may be saved. It is also of value in enabling modifications of hours and job to be made for the expectant mother; and also for making certain that she obtains the additional foods to which she is entitled. The service can only be instituted in large firms employing many women. It must be closely linked with public health authorities and the general practitioner, and should be approved by the local Medical Officer of Health. Such a service has been described by O'Sullivan and Bourne (1944).

‡ Physiotherapy is the most frequently installed of the 'ancillary services,' although wrongly so called. It is, in fact, such an essential part of equipment that it cannot be regarded as coming within the scope of this paper. Infra-red ray equipment is useful in a factory clinic in the treatment of strains and sprains, fibrositis and similar affections, and septic conditions, and the provision of facilities for giving this treatment in the works save a great deal of time lost by visiting hospital. Ultra-violêt light is the most widely provided 'ancillary service' in industry, though its value in the prevention or treatment of disease in adults is not established. Further installations in industry are therefore better avoided until its value has been proved by a scientific body of repute.

Foot Clinics

This service can be justified both in peace and war. In war-time the extra stresses, longer hours, poor shoes and the employment of a large number of people quite unused to long standing, render it particularly necessary. Even in peace-time inadequate facilities are provided for foot care, and there is an ignorance on the part of the working-class population of the relief to be gained from such treatment. Poor foot health frequently leads to faulty function, excessive fatigue, pain and discomfort. There can be no question therefore that chiropody takes a high priority among ancillary services.

Foot treatments are provided in the factory. Some cases may be referred to a doctor, but by no means all. Very little special equipment is required, so long as a small room is available for the chiropodist. This should be equipped with a stool and chair. It is essential that the chiropodist engaged should be a registered medical auxiliary. She should attend on a sessional basis and should provide her own instruments, but the material required (felt, strapping, etc.) should be provided by the factory.

During a session of 2–3 hours some 10–12 patients can be treated. Appointments should not exceed 10 minutes in duration, and if the service is to be self-supporting fees must be regulated accordingly. Experience, however, shows it to be wise to subsidize this service slightly. Foot clinics can well be provided by the small firm; one session per week is usually adequate for 1000 employees.

Ophthalmic Clinics

It has been said that the care of the teeth of the nation is satisfactory when it is compared with that of the eyes. This is due to the scarcity of men specially trained for this work. The general practitioner is not competent to treat ocular defects unless he has some special training, and the medical profession has repeatedly and rightly opposed the attempt of opticians to secure state recognition. Despite this, however, a large proportion of the public choose to go direct to an optician when troubled by their eyes, and in view of the present scarcity of suitably trained oculists this is not surprising. We have then a working population in whom eye defects are common, with inadequate facilities for their treatment. It is recognized that the correction of defective vision frequently leads to better work, more work and less spoilt work. This is particularly noticeable in fine repetition processes and in precision work generally. Furthermore, the added comfort which follows such treatment is a matter of considerable importance to the worker, and results in less lost time and fewer accidents. There is an ample case, therefore, for the provision of an ophthalmic service in industry, both in peace and war, until such time as this is made on a national scale.

The method of choice is to secure the services of an ophthalmic surgeon who would visit the factory as occasion demanded. When he did so he would not only concern himself with refractions (6 to 8 cases per session) and eye injuries, but with the various visual problems, including lighting, upon which the industrial medical officer may wish to secure his views. These visits will probably consist of a session of about 2 hours, paid for, at an agreed rate, by the employer. Glasses may be obtained through a visiting dispensing optician, or one chosen by the patient. Grants for glasses can be obtained through Approved Societies, and a similar arrangement regarding payment from wages can be made, as with the dental scheme. Alternatively the National Eye Service can be brought before the notice of the workers, and facilities granted for appointments during working hours. This scheme can be applied to the smallest factory. A third and less satisfactory method provides for sight testing to be done by an optician, usually through the Approved Society, but this is not satisfactory. National Health Insurance fees are charged and the employer is called upon to pay nothing. This, of course, is no more than a glasses service, and is inferior to the previous schemes. When such a service is installed the optician should be paid a standing fee, and should not have to depend for his remuneration upon the sale of glasses. With this safeguard it can be made into a useful makeshift while shortage of medical personnel persists.

Dental Service

The provision of a dental service in industry raises several difficult problems. In 1921 dental benefit first became available under the National Health Insurance scheme. In 1922 the British Dental Association urged the extension of dental facilities in industry. In 1937, however, it changed its policy and recommended ' that it is no longer necessary or desirable to advise employers to establish dental treatment centres, other than for the purpose of treatment of emergency cases and inspection,' since it was felt that ' any considerable extension of the system of factory clinics would place the ultimate control of the dental treatment of every worker in the hands of the big employers of labour.' It further maintained that rapid progress had been made in recent years towards the provision of adequate dental treatment for the industrial population. While there is something to be said for the present policy of the B.D.A., particularly in the provision of advisory clinics, the suggestion that adequate treatment is available, for the industrial population, cannot be maintained. In 1939 there were 18 million insured persons in the country, and of these 13 million were eligible for dental benefit (81 per cent. men, and 63 per cent. women). Only 6 per cent. applied for benefit, and 80 per cent. of the funds available were spent on extractions and the provision of dentures, because by the time application was made that was the only treatment of any avail.

Such are the conditions among the adult insured persons, but adolescents between 14–18½ are not eligible for dental benefit. Moreover, this group forms a small but important section of the industrial population. It is submitted, therefore, that the dental care available for the industrial worker is not adequate. Though this be accepted, however, there seems no reason to suggest that it is the duty of the employer to make good the deficiency.

There can be little doubt that general health is closely related to masticatory efficiency and freedom from disease of the teeth and gums, so that in any comprehensive health service the development of a national dental service should proceed side by side with that of the medical service. The white paper

on health services, in outlining this eventual development, states that 'there must be delay in reaching a stage at which general dental and ophthalmic services can be provided. . . .' In view of the shortage of dentists, and more serious, the shortage of training schools for them, there is no doubt that many years must elapse before this ideal is fully realized. This waiting period, however, may with advantage be used for experiment, and it is well that the place and value of the dental clinic in industry should be thoroughly tested. It is possible that dentists employed by an outside authority might eventually be located in a factory, just as at the present time teachers, paid by the education authority, are working in schools for 'young persons,' situated within the factory.

The white paper suggests that in view of the shortage of trained personnel priority should be given to certain sections of the community, and adolescents are specially mentioned as being one of them. Industrialists employing large numbers of juveniles may well consider that they have a social responsibility towards them and be prepared to help them to obtain dental treatment. The part to be played by the employer may vary from the provision of a clinic in the works to the granting of permission for treatment to be sought in works' time. The excellent results that have attended the Cambridge scheme, whereby dental treatment provided by the local authority has been made available to young people in industry, are very encouraging (Grandison, 1944). There young people are followed up after leaving school at 14, and are given an appointment at the dental clinic every 6 months, until they reach the age of 18. This treatment is given during working hours, and local employers have, without exception, co-operated by granting time off for these young people to keep their appointment. Extension of similar facilities to other areas would be welcome. The part of the employer here is not an onerous one, and there must surely be few who would refuse to co-operate in such a scheme. Reform in our educational system will doubtless eventually bridge the gap between the years of 14 and 18½, but until the whole of this important period is catered for, the adolescent can best be approached through his employer.

In general the position may be summed up thus:—

1. In war-time it is not justifiable to start up a full dental clinic in industry, unless the factory is isolated, or juveniles predominate, though an emergency service may be desirable.

2. In time of peace it will probably be a wise and welcome provision, particularly if there is a large juvenile section. If the labour turnover is small, and if juveniles are retained with the firm on reaching the adult state, definite benefits accrue to the employer.

The service provided may be of varying types:—

(*a*) Full or part-time dental surgeon who undertakes all types of treatment for employees.

(*b*) Emergency treatment and advice only.

(*c*) Extension of National Health Insurance benefits to all employees, with arrangements for payments to be made by deduction from wages, with free treatment for all juveniles (under 18).

(*d*) Arrangements for juveniles to receive dental treatment in works' time.

In the full service, prophylactic, conservative and prosthetic treatment is offered. Stress is placed on the retention of teeth and education must be regarded as one of the most important functions of the service. Education of the worker should not be confined to his own personal requirements, but should emphasize his responsibility for the dental health of his children.

It has been suggested that in industry the dental service is not part of the industrial health service, and there are several instances in which a dental surgeon carries on a practice in the works, or among a section of the employees, and remains quite independent of any general health policy. This is a mistake. In industry the dental service is a true ancillary health service, and while the dentist is naturally left to decide all details of treatment and retains control of his department, the industrial medical officer must be consulted on matters of broad policy, and the dental surgeon should be administratively responsible to him. It is estimated that in a general factory of five thousand workers a whole-time dentist is required, whereas this total may be as low as three thousand if there is a special hazard, such as lead or phosphorus (Baron, 1944). Wherever possible the dental surgery should be in the works, situated centrally.

The small factory raises special problems. In this case inspections may be carried out on the site while operative work is done at an outside surgery, or arrangements can be made with a nearby dentist to set aside certain times for employees. The grouping of small industries might be considered, but experience shows that this is rarely satisfactory. It has been suggested that a mobile dental surgery sent out by the local dental hospital might have possibilities and that the experiment should be tried out, but experience with this method in rural districts for the school dental service would throw some doubt on its efficiency.

Conclusions

It is important that the opportunities for constructive health work offered in industry should be more widely realized. Here people are gathered together in groups, and it is here that health education can best be attempted. This should go on persistently and unobtrusively. Ancillary health services offer great scope for practical education of this type, and in this way can play an important part in promoting the health of the community.

In dealing with ancillary health services, as with all industrial welfare activities, we must retain a sense of proportion. It is no good providing the most comprehensive schemes if the basic relationship between employer and employee is wrong. Nor are these services likely to be of much avail unless the worker is well fed and well housed. These are the big things, and let no one install any or all of these ancillary schemes if it is likely to act as an excuse for the neglect of these major matters.

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GYNAECOMASTIA IN STILBOESTROL WORKERS

BY

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Twenty cases of gynaecomastia among 38 men engaged in the manufacture of stilboestrol are described and the manner in which control of this industrial hazard was achieved. The account is based solely on clinical examination of the breasts, except in three cases where histological reports were obtained.

In February 1940, some of the men working on the stilboestrol plant noticed that their breasts were becoming enlarged. Therefore all those who had been exposed to stilboestrol at any stage of research or manufacture were examined, and in most, swellings in the mammary area were found. Later, work with dienoestrol also caused symptoms in one research chemist. This established that there was an occupational risk in the manufacture of all oestrogens.

While it was known that the administration of large amounts of oestrogens caused overgrowth of the fibrous supporting tissue of the breast, it had not been realized that small amounts of stilboestrol, absorbed during manufacture under apparently good conditions, could cause such marked physical signs. Dunn (1940) reported gynaecomastia and diminution of sexual function after a course of 5 mg. stilboestrol daily by the mouth for about two months, and since then references have been made in the medical journals to enlargement of the breast during the course of stilboestrol therapy for prostatic cancer.

The first twelve cases, two of which were described by Scarff and Smith (1942), occurred in 1940, the others appeared one by one in the following three years ; the last three, two in March 1942 and one in July 1943, were caused by accidental defects in the methods of protection adopted. The fact that one was submitted to operation shows the necessity for considering occupational gynaecomastia in the differential diagnosis of breast swellings in the male.

Clinical Findings

The first group of men examined included chemical process workers, research chemists, analytical chemists and pharmacists; the periods of exposure varied from two weeks to eighteen months. The first symptom was tingling in the nipple, often hardly noticeable unless chafing by braces occurred, when the tingling became soreness. This sometimes developed within four days of exposure, but more usually took about three weeks. Some complained of tingling in the nose and flushing, and one of frequency of micturition and temporary impotence. At the start there were often no physical signs. Later, a small area of thickening could be felt, usually under the areola, often unilateral ; this might subside within a few weeks if absorption had been minimal, or the thickening might enlarge into a nodule which sometimes enlarged further into a hemispherical swelling with all the appearance of the female adolescent breast, or expanded into one quadrant forming a well marked mass. Later still, a sub-areolar plaque about the thickness of a florin might be felt which gradually became smaller, often resolving into a small area of induration around the nipple before finally disappearing. Occasionally a swelling developed away from the region of the nipple, along the edge of the pectoral muscle, apparently in the axillary tail of the breast.

In addition to the asymmetry so commonly present there appeared to be a difference in reaction in each breast, shown by different rates of growth and regression. Case 2 (*v.i.*) showed this feature well; the right breast had all the appearances of a well-established lesion for at least three weeks before there was any appreciable abnormality in the left. In Case 13 a hard mass formed in ten days, and in Case 1 well marked swelling and feminization developed during one month of exposure. On the other hand, tumour formation was delayed for some months after removal from exposure in Cases 9 and 18. The plaque stage subsided in about two months in Case 13, whereas in Case 19 it lasted for nine months. This stage was reached after eighteen months in Case 1, but histologically there was evidence of marked stimulation of mammary activity. This man left, and he and two others who also left shortly after being affected are the only men in whom there are no residual abnormal physical signs.

The plaque stage would appear to represent the final contraction of the fibrous tissue but, if this is so, it throws a doubt on whether early physical signs are readily detectable. In Case 18 examinations at short intervals were made and the first sign detected was a plaque some four months after exposure ; in Case 2 it seems unlikely that the left breast was unaffected until five weeks after the right, and that a new lesion appeared there while that in the right was subsiding; it is more reasonable to suggest that the proliferation of fibrous tissue in the left mammary area was at first undetected.

Routes of Absorption

It soon became obvious that the drug could be absorbed from numerous sources during the final stages of manufacture and in handling the finished product. Certain solutions could permeate the

skin rapidly and resinous solutions were difficult to remove from the skin. When spills or splashes occurred on overalls, gloves, benches or apparatus, evaporation of the solvent left a powder which could be absorbed through the respiratory tract or through the skin, particularly if there was friction from cuff or collar. The powder is electrostatic and too light to be controlled by any draught control or exhaust apparatus. Atmospheric contamination was therefore common and difficult to eliminate.

Preventive Measures

Ordinary precautionary measures thought suitable for the handling of any powerful drug in light powder form had been taken before the trouble was reported. When the risk was found to be so great more stringent precautions were enforced. Closed apparatus was used where possible; protective overalls, gloves, and masks were supplied, and cleanliness of benches, apparatus and workrooms was enforced. Contaminated cleaning materials were destroyed. However, fresh cases of gynaecomastia continued to appear in men who were apparently intelligent, clean and careful workers. Women were not permitted to do the work, because detection of signs of absorption would be difficult. Finally, at the end of 1940, a new stilboestrol department was designed. Work started and by April 1941, a carefully planned routine was prepared and an attempt was made to assess the degree of atmospheric contamination by animal tests.

The department consisted of: (1) an undressing room, where all clothing was put into lockers, and clean vests, flannel trousers, tennis shoes, overalls and caps were assumed; this led through (2) a shower-bath (not used on the way in) into (3) the main workroom. This contained (4) a small drying room, later fitted with an air-lock door and an outlet for carrying away hot air. Only in this small room was the powder handled, the operator before entering donning an extra overall, gloves and respirator, kept in the large clean room. The gloves and respirator were cleaned when he returned from the small room and the cleaning rags deposited in a bin. At the end of a shift all clothing was deposited in a sack, the operator walked into the shower and thence back to the dressing room where he dried and dressed himself. The sack of contaminated clothing was removed and washed by a woman trained for the purpose. The floor was tiled and it was hosed at the end of each shift. Unfortunately there were many overhead pipes which caused difficulty during the periodic cleanings that were found to be necessary. Apparatus was washed immediately after use. All spills were wiped up and the rags deposited in the bin.

The staff consisted of selected volunteers, chemists or pharmacists, familiar with the care necessary in handling powerful drugs, and two cleaners. Work in the department was restricted to two weeks at a time, followed by at least one week on other work. The shift lasted from 7.30 a.m. to 1.30 p.m., and during this time no one left the department for any purpose, nor did anyone enter it. Men with physical signs were not allowed to continue this work; but there was one man who worked without symptoms from November 1940, to the summer of 1943.

Animal Tests

After preliminary experiments groups of ovariectomized mice were placed for periods of three days in various parts of the main room, usually outside the drying cabinet door and near the cleaner's sink—the former position being that where contamination from dust was most likely to occur, the latter the point furthest from this source of contamination and also where contamination from an unskilled worker might be expected. The vaginal smear technique was used and in May and early July 1941, all tests were positive. After the main room was cleaned they remained negative until early October. During October and November they fluctuated, sometimes one group being positive, sometimes the other, sometimes both. During this period efforts were made to discover the cause of the positive tests and various counter-measures were tried. A wet blanket was hung outside the drying cabinet door; later the air-lock door was added. The two cleaners were watched to see if one was dislodging more dust than the other. An attempt was made to space the cleaning of the department according to the tests, but this was not successful. In January 1942, the tests were again positive; this was possibly due to two factors, increased production and absence through sickness of one cleaner. Owing to the scarcity of mice, the tests were omitted until May 1942, but from then on until June 1943, all were negative. They were then discontinued. Occasionally it was suggested that the tests were inconclusive. An amount of stilboestrol that caused oestrus in mice need not cause symptoms in the men. Nevertheless we found that the tests were negative when performed early in the week after the department had been shut for the week-end and that after the mouse test had been positive a thorough cleaning was followed by a negative one. The aim was to achieve an atmosphere free from stilboestrol; without the animal tests conditions might have been thought to be perfect. Cumulative absorption of minute amounts—found on one occasion to be 0·2 mg./300 cu. feet air, and on another to be unweighable—might have affected the men in whom clinical examination did not reveal any abnormality.

Summary

Twenty cases of gynaecomastia occurring among 38 men engaged in the manufacture of stilboestrol are described. An account is given of the preventive measures found necessary to protect the work-people.

I wish to express my appreciation of the co-operation given in the investigation and prevention of this hazard by many of my colleagues in several technical departments of the laboratories.

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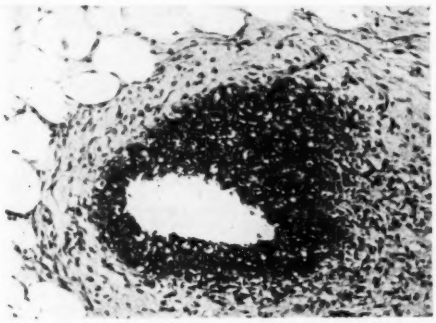
CASE NOTES

Case 1. *February* 19*th*, 1940: aet. 18. On production. Exposure 1 month. Complained of pain and swelling in the breasts and tiredness. Both breasts visibly enlarged. In each a soft localized hemispherical tumour, about 1-inch diameter, taking the shape of the breast. *April* 8*th*, 1940: no change. Biopsy was performed and the report from the Bland Sutton Institute of Pathology was as follows:—'The breast tubules show a marked degree of epithelial overgrowth with, in places, solid acinar formation. Areas show an indistinct basal



(*By courtesy of the British Journal of Surgery*).

FIG. 1.—Showing Case 1. Man aged 18.

membrane, but nowhere is there any definite invasion of tissue by epithelial cells . . . there is evidence of stimulation of mammary activity . . . severe in (this case).' (S.S. 318/1940). *September* 4*th*, 1940: right breast still enlarged; swelling around biopsy scar which is tender; both breasts tender. *June* 28*th*, 1941: right breast tender swelling, 2-inch diameter, mainly superior to, but partly deep to scar. Left breast, smaller tender swelling. Patient then left. He was the only one in whom signs persisted for so long.

Case 2. *February* 19*th*, 1940: aet. 23. On production. Exposure 3 months. Complained of tender swelling of right nipple, tingling in nose, flushes, tiredness and gain of weight. Right breast visibly enlarged; hard localized tender hemispherical swelling, 1½-inch diameter. Left breast no abnormality. *March* 1*st*, 1940: right swelling smaller, 1 inch in diameter. *March* 21*st*, 1940: left breast now enlarged; he had noticed this for 14 days; hard tender nodule under and equal in size to areola. Right slightly smaller; tender hard mass underlying areola and extending outwards for ½ inch. *July* 29*th*, 1940: no signs.

Case 4. *February* 26*th*, 1940: aet. 17. On production during alternate weeks for 3 months. He had no symptoms. There were no visible signs, but in both breasts there was a well defined nummular plaque, 1 inch across, about the thickness of a florin, deep to the areola. *March* 21*st*, 1940: smaller. *September* 4*th*, 1940: no physical signs.

Case 6. *February* 27*th*, 1940: aet. 27. Laboratory work, mainly with alcohol and ether solutions, for 2 months. Had noticed tenderness in breasts after 3 weeks' work. Then started wearing gloves. No symptoms now. Breasts, no visible signs, small hard nodule, ½-inch diameter. *March* 11*th*, 1940: plaques as Case 4, palpable axillary glands. *April* 8*th*, 1940: no change. Biopsy performed and the report from the Bland Sutton Institute of Pathology was as follows:—'Section shows gland tubules in a moderately cellular stroma. For the most part the tubules are regular in appearance and lined by a single layer of cubical epithelium, but there are areas of epithelial overgrowth and occasionally solid columns of cells . . . there is evidence of stimulation of mammary activity . . . slight in (this case).' (S.S. 315/1940). *April* 25*th*, 1940: no sign except biopsy scar. After a holiday he returned with no symptoms at all. *March*, 1944: no abnormality except occasional irritation in breasts.

Case 9. *February* 29*th*, 1940: aet. 24. Production intermittently for 1 month. No signs or symptoms. He left in April and wrote at the end of June that he had developed a lump in his breast and was going to be operated on. Reports sent to me later by the doctor said that on July 2nd a local excision of the left breast was performed for mastitis, and the section showed a simple fibro-adenoma with no evidence of malignancy; that in September the wound was soundly healed and that there was no sign of inflammation. *January*, 1941: he came to see me and told me that he had noticed nothing wrong until June, 1940; the left breast then became sore, tender and visibly swollen; he could feel a hard lump in the centre of the swelling about the size and shape of a florin. No symptoms or signs.

Case 13.* *January* 1*st*. 1941: aet. 23. Production 3 months, but had not been exposed to any of the oestrogenic stages of manufacture until an accident on *December* 20*th*, 1940, when he had been splashed with a resinous, sticky mixture containing stilboestrol which was removed from his skin with great difficulty. Three days later he had pain and tenderness in both breasts. In each breast there is a hard nodule, 1-inch diameter, and the whole breast is swollen and tense; much subcutaneous fat. *January* 15*th*, 1941: nodules larger. *January* 29*th*, 1941: nodules smaller but breasts still full. *February* 25*th*, 1941: left nodule gone; right, small plaque where nodule was. *March* 24*th*, 1941: only general fulness of the breasts. *May* 28*th*, 1941: breasts now 'back to their normal state'; diffuse mass palpable under subcutaneous fat. *August* 28*th*, 1941: no fulness and less fat.

Case 18. *March* 12*th*, 1942: aet. 29. Production in new department 6 months with no trouble. After removing respirator he noticed a fair quantity of white powder inside the filter. Subsequent inquiry showed that an alteration had been made in the material used for the filters without any warning of the change having been given by the manufacturers. Since then Mark IV Dust respirators have been used exclusively. Breasts—no signs; lower borders of both pectoralis muscles felt thickened. *March* 27*th*, 1942: no physical signs. *July* 15*th*, 1942: left hard plaque, 1 inch in diameter. He had continued work but was advised to stop. Animal tests in May and July were negative; none were carried out in June. *July* 22*nd*, 1942: plaque smaller, softer. *August* 7*th*, 1942: very small. *September* 1*st*, 1942: no signs.

Case 19. *July*, 1942: aet. 34. After 4 months' work he reported irritation in right breast. There was a hard tender plaque, 1 inch in diameter, in the breast. *September*, 1942: small thick plaques, ½-inch diameter, in both breasts. *March*, 1943: no signs in breasts.

Case 20. *July* 8*th*, 1943: aet. 25. Production in new department 15 months. Routine periodic examination revealed plaques, ¾-inch diameter, both breasts. He had noticed no abnormality. Previous examination in May had revealed no abnormality. He thought the trouble might have been caused by an accident when a flask broke some time before. However, it was soon discovered that during the absence of his chief, heavy pressure of work had led him to perform in the main room part of the process that should have been performed in the cabinet. *July* 20*th*, 1943: plaques smaller and softer. *August* 28*th*, 1943: little induration around nipples. *October* 23*rd*, 1943: no signs.

* Cases 12–20 occurred after the new department was opened.

INVESTIGATION FOR SIGNS OF BENZENE INTOXICATION IN WORKERS USING AEROPLANE DOPE AND RUBBER SOLVENTS

BY

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The purpose of the investigation was to assess the evidence of benzene poisoning in workers handling aeroplane dope and the rubber solvents used in covering self-sealing petrol tanks. These substances contain benzene in variable quantities. The amount depends on the supplies of xylene, toluene, benzene and other solvents available, though the amount of benzene in aeroplane dope, in spite of the difficulties of war conditions, does not exceed 15 per cent. In the case of the industrial rubber solvents the amount of aromatic hydrocarbons is not more than 5 per cent.

H. J. Barrie visited six factories in Yorkshire. He interviewed and noted the age, number of children, length of time in present employment, type of previous occupation, and symptoms of 183 women and 53 men employed in dope shops. A similar number of workers of the same sex and economic group who were employed in the same factories, but who were not exposed to dope, were examined and used as controls. On each group he made full blood counts, and obtained samples of urine from each of the workers for the estimation of the inorganic-total sulphate ratio. J. F. Loutit and T. S. Marshall in Surrey made similar investigations on a smaller scale in two factories. They examined 44 women and 21 men; but did not examine controls or collect urine samples, as no abnormality was apparent and they were engaged on other pressing work. D. Hunter and K. Perry also made investigations at eight factories in Hertfordshire on 164 women and 43 men using aeroplane dope, and 193 women using rubber solvents, and examined a similar group of 174 women as controls. R. Milton obtained samples of urine from 100 women in factories, and from 100 women hospital patients as controls, and investigated the inorganic-total sulphate ratio. He also made investigations into the amount of benzene present in the atmosphere, both in the general shop and where specific jobs of short duration were being carried out, such as spraying the inside of cockpits and the under surface of wings in the horizontal position. Unfortunately, through circumstances beyond our control, the investigation of blood and concentration of benzene in the atmosphere did not coincide, and while the composition of the rubber solvent did not change, there is reason to believe that the amount of benzene in the dope was substantially less at the time of the atmosphere estimations than that present at the time of the blood counts.

Review of Literature

Before describing the results of these investigations a short review of the literature of benzene (or benzol) will be given. Schrenk, Yant, Pearce and Sayers (1940) have shown that the response of dogs and guinea-pigs exposed to crude and commercial benzols is characteristic of benzene poisoning and the pathological effect is due to the benzene content of the solvent used and not to impurities. Toluene and higher homologues of benzene have no such action, provided they contain no benzene. Commercial toluol may contain up to 15 per cent. benzene, and this may explain the serious toxic effects in industrial workers which have been attributed to the inhalation of toluene. The risk of chronic poisoning with this group of solvents depends therefore on their benzene content. Massive exposure to benzene results in acute poisoning with symptoms of excitement, incoherent speech, flushed face, headache, giddiness, nervousness, insomnia, nausea, paraesthesiae in hands and feet, and fatigue with ultimate narcosis and death. This syndrome is not likely to arise under conditions considered in this paper. Chronic benzene poisoning, on the other hand, is an important condition, and no satisfactory method has been devised so far to detect it in its earliest stage. It is accepted, however, that repeated exposure to benzene may cause poisoning mani-

fested by severe and often fatal anaemia resulting from its toxic effect on the bone marrow.

The early work on chronic benzene poisoning by Santesson (1897) and Selling (1910 and 1916) established the conception of a severe and usually fatal aplastic anaemia. They considered that the effect on haemopoiesis was progressive, affecting first the platelets, then the granular leucocytes, and finally the red cells. It was thought that a diagnosis of benzene poisoning was not justified unless there was an aplastic anaemia associated with a granulocytopenia, the latter being the more important for diagnosis. The cases invariably showed purpuric haemorrhages, bleeding gums, epistaxis or menorrhagia. The spleen was never enlarged, and the bone marrow was always aplastic. Young women were more susceptible than men to the vapour of benzene and a concentration in the air of 100 parts per million or less was considered safe. Later work on manifest poisoning made it clear that anaemias caused by benzene may not follow one pattern. They may be macrocytic or microcytic, and the different components of the blood may be affected in varying degree.

Detailed studies upon 89 workmen exposed to benzene were made in 1939 by F. T. Hunter. In the same year Erf and Rhoads reported the findings in 9 patients poisoned by benzene, and Mallory, Gall and Brickley reported on 19. The last-mentioned workers found the picture in the bone marrow to vary from severe hypoplasia to the most extreme hyperplasia. Hyperplasia was commoner, and they even recorded extramedullary haemopoiesis. Hyperplastic reactions were more common in males and were only found in patients after prolonged exposure, whereas hypoplasia followed either short or long contact and was more common in females. At necropsy the spleen was often enlarged, lymph nodes were prominent and dusky pink on cut section. Purpura of skin, mucous membranes and serous surfaces was often noticed. Gangrenous stomatitis was present in some of the worst cases.

In the cases reported by Erf and Rhoads the haematological findings were very variable. Thus, in 9 patients the haemoglobin values ranged between 47 per cent. and 81 per cent., the red-cell count from 1,850,000 to 4,130,000 per cu. mm., the white-cell count between 1,750 and 6,500 per cu. mm., the platelet count from 18,000 to 150,000 per cu. mm., and the reticulocytes from 3·8 to 14 per cent. Free hydrochloric acid was found in the gastric juice of all the patients, though two were achlorhydric until histamine was injected.

There are many indications that circulating red cells may be destroyed at an abnormally rapid rate in patients poisoned with benzene. Many authors have recorded increased numbers of circulating reticulocytes, a finding which was assumed to indicate abnormally active haemopoiesis. A raised plasma-bilirubin and an increased excretion of urobilinogen in the urine has been reported. Haemosiderosis of the liver, spleen, kidneys, and bone marrow is a frequent pathological alteration, both in human beings and in experimental animals dead of benzene poisoning.

The evidence that chronic exposure to benzene produces leukaemia in human beings is still incomplete, but it is accumulating rapidly and to a volume which commands serious consideration. Penati and Vigliani (1938) were able to collect 10 cases of leukaemia in patients exposed to benzene. Several varieties of the leukaemic state have been recorded —chronic myeloid, chronic lymphatic, and acute myeloblastic. Four more cases may now be added to this list, namely, two published by F. T. Hunter, one by Mallory, Gall and Brickley, and one by Erf and Rhoads, all in 1939. One of Hunter's patients showed a typical acute leukaemia; he had been heavily exposed to benzene for four years, lightly for a further six years, and not at all for the 20 months before his illness. Mallory tells of leukaemia in a boy of 12 years who repainted his toys after taking off the old paint with a solvent found to contain benzene. Fourteen cases of leukaemia developing among the many thousands of people exposed to this solvent do not seem impressive, but they gain in significance when we bear in mind that Lignac (1932) produced leukaemia in mice poisoned with benzene. Salter (1940) suggested that the benzene in the marrow may play the role of a carcinogen and thus cause leukaemia.

Victims of benzene poisoning often constitute a small majority of the workers. A single susceptible individual may develop fatal poisoning in an environment which does not give rise even to mild poisoning in others (Ronchetti, 1922). The factors responsible for the great variations in susceptibility are unknown, but the original idea that women are more susceptible than men has been disproved (F. T. Hunter, 1939). Changes in the blood may begin from two days to one month after the first exposure and may progress or develop after exposure has ceased.

Death may occur within three weeks of the onset of symptoms. The case mortality rate is as high as 10 per cent. Occasionally a severe case ends in recovery. Hayhurst and Neiswander (1931) recorded a case in a rubber worker in whom the red cells were 900,000 per cu. mm., haemoglobin 10 per cent., white cells 850 per cu. mm., bleeding time more than 25 minutes, and platelets 100,000 per cu. mm. Treatment by blood transfusion and iron was followed by recovery, and three and a half years later the blood count was normal except for slight granulocytopenia.

If the severe progressive anaemia of manifest poisoning may show such variations in type, it is not surprising to find that the claims in regard to the haematological signs of early poisoning are even more diverse. In most cases leucopenia has been regarded as the most reliable sign of early or occult poisoning, but nearly every abnormality of the blood picture has been cited. Many investigators apparently have not realized the necessity of strict controls to the group they have studied. From experience of a group of 267 rotogravure workers of mixed European descent who worked in a New York cellar exposed to concentrations of benzene vapour up to 1,000 parts per million, Greenburg, Mayers, Goldwater and Smith (1939) deprecated reliance on the leucocyte count as a rapid means of detecting cases of poisoning; leucopenia, they said, is more often found in severe than in early cases. They regarded a reduction in the number and an increase in the size of the red cells as earlier and more sensitive signs of poisoning, and they looked with suspicion on macrocytosis in a benzene worker even in the absence of other abnormalities.

Eosinophilia, erythrocytosis, and leucocytosis occasionally accompany the condition, but rarely stand as isolated phenomena. Of the 98 cases

recorded by Greenburg and his colleagues (1939), 24 had an eosinophilia count over 3 per cent., 7 had a red cell count over 5,200,000 per cu. mm., and 28 had a white cell count over 9,900 per cu. mm.

Recently Hamilton-Paterson and Browning (1944) claimed that workers exposed to benzene from rubber solvents showed a significant leucopenia with a relative lymphocytosis. However, they did not estimate how much benzene was present in the air. If the conditions were similar to those we are describing the amount would be insignificant, and therefore these changes could not be attributed to benzene.

Apart from haematology, Schrenk, Yant and Sayers (1936) found that after exposure of men and animals to benzol, there occurred an increase in the organic sulphate excreted in the urine. The ratio of inorganic to total sulphate, usually about 80 per cent., was thereby lowered. They compared their findings in the urine with blood counts on the same patients. They also estimated the amount of benzene in the atmosphere to which these individuals were exposed and found that all three were correlated. They concluded, however, that the sulphate ratio in the urine was a more accurate guide to exposure than was the blood count.

Atmosphere Concentrations of Benzene

The environmental study in connection with this problem has been carried out in two factories using rubber solvents, and in seven using aëroplane dopes, lacquers and thinners. In the case of the rubber solvent factories, the employees were engaged in hand brushing rubber solutions on to large surfaces, allowing the solvent to evaporate until the tacky stage, and then covering with materials to give adhesion.

The solvents used contain 5 per cent. benzene and this partly evaporated and partly permeated into the rubber materials. The tendency to a definite evaporation gradient was avoided by the ventilation system which brought a continuous current of warm air from above directly on to the evaporating surface, and out of the shop at floor level. By this means it was possible to avoid local high concentrations of benzene. The ventilation systems in these factories have been noted, and with the air change rate provided it was theoretically possible to have a continuous benzene concentration of 20 parts per million throughout the whole air space, if it was assumed that all the solvent used evaporated. This figure was obtained from the data given in Table 1 by calculating the volume of solvent which would be present in the total air volume if all the solvent evaporated. The benzene concentration will be 5 per cent. of this figure. Many estimations of the benzene concentration at different points in these factories were made, using a method (Milton 1945) which is specific for benzene. It has been shown that the concentration was remarkably consistent at the working level, be this near to the operator's mouth, between operation benches, or near the exhaust fans at ground level.

Air samples were taken over long periods in order to obtain a comprehensive knowledge of the average hazard to which the worker was exposed, because it was considered that this represented a more accurate picture of the environment than the statistical average of a number of snap samples.

As will be seen on reference to Table 1, the benzene concentration in these factories never exceeded 3 parts per million at any time, and in view of the large amount of the solvent used, and the manner in which it evaporated from large areas constantly throughout the day, this is a proof of the effectiveness of the ventilation system.

The situation in dope shops of aeroplane factories was not so straightforward since the work tended to be intermittent, and in consequence the concentration of solvent in the atmosphere varied between wide limits throughout the day. Moreover, there were local conditions of work distribution, shop

TABLE 1

ATMOSPHERE CONDITIONS IN FACTORIES USING RUBBER SOLVENTS

Factory	Capacity in cu. ft.	Air changes per hour	Consumption of solvent per hour in gallons	Volume of air per gallon of solvent in cu. ft.	Concentrations of benzene found (Parts per million by volume)	
1	278,000	8	13·0	170,000	(*a*) At operator's mouth height	2·8 p.p.m.
					(*b*) General atmosphere 10 ft. from painted surface ..	1·5 ,,
					(*c*) General atmosphere 10 ft. from painted surface ..	1·7 ,,
					(*d*) General atmosphere near exhaust fans	2·3 ,,
					(*e*) General atmosphere between benches	3·1 ,,
					(*f*) General atmosphere 10 ft. up .. .. .. (30-minute samples)	2·5 ,,
2	171,000	8	14·4	99,000	(*a*) Near operator	2·3 ,,
					(*b*) Near operator (mouth level)	2·1 ,,
					(*c*) Between benches	2·3 ,,
					(*d*) Near exhaust fan ..	2·9 ,,
					(*e*) General atmosphere .. (30-minute samples)	2·7 ,,

layout, and ventilation which affected the operational hazard. An environmental study was made in seven dope shops all having different conditions. The work consisted of (*a*) hand doping, i.e. brushing cellulose dope on to aircraft parts and covering with linen, and (*b*) spraying cellulose paint on the wings and the fuselage. Doping was carried out largely by women who constantly stand over the evaporating surface as they work. Spraying was usually carried out by men, and was rarely continuous, time being allowed for a surface to dry before a further coat was applied. In the vicinity of the spray gun high concentrations of paint occurred in the form of mists, and although workers were provided with gauze particulate respirators these were rarely used, partly because of disinclination and partly because they were ineffective. They were, of course, useless against vapours. A number of coloured paints of varying solvent content were used. Towards the end of 1943 benzene as a basic solvent was practically eliminated in these factories and xylene substituted. The xylene content of the paints varied from 6 to 60 per cent. according to the type, and the thinners sometimes contained up to 90 per cent. of xylene. Therefore the benzene found in the atmosphere was due either to impurities in the

TABLE 2

ATMOSPHERE CONDITIONS IN AIRCRAFT DOPE SHOPS

Shop	Capacity in cu. ft.	Air changes per hour	Consumption of solvent per hour in gallons	Volume of air per gallon of solvent in cu. ft.	Concentration of benzene found (30-minute samples) (spraying 15 minutes) (Parts per million by volume)	
A	78,000	35	3·6	760,000	Dope workers (mouth level) ..	1·6 p.p.m.
					,, ,, ,, ..	2·6 ,,
					,, ,, ,, ..	1·9 ,,
					,, ,, ,, ..	2·3 ,,
					Close to spray gun worker ..	31·5 ,,
					General atmosphere near spray	7·5 ,,
B	220,000	30	2·0	3,300,000	General atmosphere during spraying	2·5 ,,
					General atmosphere 10 mins. after spraying	2·0 ,,
					Close to spray gun worker ..	9·0 ,,
					,, ,, ,, ..	9·0 ,,
					Atmosphere near spray gun ..	4·0 ,,
					,, ,, ,, ..	2·0 ,,
C	857,000	(20-30)	10·5	2,000,000	General atmosphere	1·5 ,,
					Close to sprayer	2 8 ,,
					Under fuselage (near sprayer)	2·9 ,,
					Behind spray gun	1·8 ,,
					Brush painting in fuselage ..	1·8 ,,
					,, ,, ,, cockpit ..	2·0 ,,
D	136,000	20	5·6	490,000	Doping under wing	1·4 ,,
					Spraying under wing	3·2 ,,
					,, ,, ,, ...	4·7 ,,
					Close to sprayer's mouth ..	11·0 ,,
					,, ,, ,, ..	9·0 ,,
					Spraying in engine box under wing	28·8 ,,
					General atmosphere while spraying	10·0 ,,
					General atmosphere 10 mins. after spraying	2·2 ,,
E	145,000	30	3·2	1,360,000	Doping (near mouth) ..	0·3 ,,
					,, (ground level) ..	0·4 ,,
					,, (general atmosphere)	0·2 ,,
					Mouth level during spraying..	8·0 ,,
					Ground level during spraying	5·0 ,,
					General atmosphere 10 mins. after spraying	0·9 ,,
					General atmosphere 30 mins. after spraying	0·1 ,,
F (*a*) small shop	17,000	?4	0·4	170,000	General atmosphere (doping)	2·0 ,,
					Near doper's mouth	2·2 ,,
					Near evaporating surface ..	2·1 ,,
(*b*) large shop	132,000	12	3·0	530,000	General atmosphere after spraying	2·1 ,,
					General atmosphere during spraying	10·0 ,,
					Close to sprayer's mouth ..	10·1 ,,
G	21,000	35	35·0	210,000	General atmosphere (doping only)	3·4 ,,

solvents or to an occasional paint which contained benzene. The supplies of solvents available was also a factor in the composition of the paints, and occasional reversions to benzene formulae were made. Although toluene was not used as a solvent, it nevertheless was demonstrated in the atmosphere, presumably arising from an impurity in the solvent.

As this investigation was concerned with the benzene hazard the concentrations of xylene and toluene were not measured. In some of the samples taken close to the sprayer there is reason to believe that the concentration of xylene was at least ten times that of benzene.

As in the case of the rubber solvent investigation, air sampling was carried out at many points in each of the factories, and wherever possible at least half-hourly samples were made to obtain average concentrations. Spraying was rarely more than a fifteen minute job, and the peak concentration was obtained in order to compare this with the general atmosphere in the dope shops. The temperature in these factories was maintained between 65° and 75° F., this being the optimum working range, and the ventilation was of the forced type with very frequent air changes. Among the factors which affected ventilation was the layout of the shop. In one factory aircraft wings stood with their lateral axes in a vertical plane, with forced ventilation bringing air in at roof height, passing on each side of the wing, and out through slats in the floor. Here the concentrations were very low. In another factory the wings were stood on trestles, and this made the sprayer work in box-like conditions under the wings, giving rise to temporary local high concentrations of solvents. In some factories hangar doors were frequently opened, and this obviously had a lowering effect on the concentrations found.

In general the benzene concentration in the atmosphere of these shops throughout the day was of the order of 3 parts per million. During spraying the general atmosphere concentration rose to about 10 parts per million. Close to the doper the concentration was usually of the order of 2–3 parts per million, but by the sprayer's mouth during the operation this was of the order of 10 parts per million. In specific jobs, e.g. spraying in engine boxes under the wing, the concentration was as high as 30 parts per million, although in this particular case we believe that a paint with 12 per cent. benzene was used. The details of these investigations are set out in Table 2. These were benzene concentrations from the use of paints and dopes in which the benzene was usually an impurity, xylene being the basic solvent. Since the vapour pressure of xylene is so much lower than benzene, it is probable that during doping operations the concentration of this solvent was low, whereas during spraying it was possibly as high as 100–200 parts per million.

Spraying was, however, intermittent, and this concentration could not have been maintained for long in view of the frequent air changes in the shops brought about by the ventilation systems.

Details of conditions such as cubic capacity of shop, air changes per hour and quantity of dope used in the dope shops examined in Yorkshire and in Surrey are given in Tables 3 and 4 respectively.

TABLE 3
CONDITIONS IN FACTORIES IN YORKSHIRE

Factory	Capacity in cu. ft.	Air changes/hr.
1 (*a*)	652,392	—
(*b*)	6,084	—
2	7,280	—
3	9,100	—
4	10,000	15
5 (*a*)	170,135	30
(*b*)	154,176	30
(*c*)	42,275	30
6	3,940	—
7 (*a*)	17,000	—
(*b*)	229,400	30
(*c*)	72,100	30
(*d*)	42,200	30

TABLE 4
CONDITIONS IN FACTORIES IN SURREY

Factory	Capacity in cu. ft.	Air changes/hr.	Consumption of solvent/hr. (in galls.)
1	500,000	5	12·5
2 (No. 1 shop)	151,200	5 (no spraying allowed)	4·0
(No. 2 shop)	177,260	10 (brush and spray on 2 fuselage only)	4·0

Age and Sex Distribution

The age and sex distribution of the workers examined in the group of factories in Hertfordshire were as follows :—

FEMALES

Ages	18–29	30–39	40–49	50–59	60 and over	Total
Controls ..	126	27	9	2	—	164
Dope workers ..	102	39	22	9	2	174
Industrial rubber solvent workers	101	43	33	16	—	193

MALES

Ages	18–29	30–39	40–49	50–59	60 and over	Total
Controls ..	22	18	13	4	3	60
Dope workers ..	4	7	18	10	4	43

In Yorkshire and Surrey the distributions were as follows :—

FEMALES

Ages	18–29	30–39	40–49	50–59	60 and over	Total
Yorkshire controls	100	28	13	4	0	145
Yorkshire dope workers ..	113	42	19	9	0	183
Surrey dope workers ..	29	11	4	—	—	44

MALES

Ages	18–29	30–39	40–49	50–59	60 and over	Total
Yorkshire controls	6	12	10	8	2	38
Yorkshire dope workers ..	9	13	24	6	1	53
Surrey dope workers ..	2	7	6	5	1	21

Blood Findings in Present Investigation

In view of these findings of the concentration of benzene in the atmosphere, it was not to be expected that any changes would be found in the blood counts or inorganic-total sulphate ratio in the urine of these workers. Many of them complained of vague symptoms such as lassitude, nausea, headache and fatigue, but these are just as likely to be caused by the other constituents of the dope such as butyl acetate; and in those between the ages of 35 and 50 menorrhagia was not uncommon, but this symptom is fairly widespread in the general population between those ages. The workers were split up into several groups for the purpose of plotting frequency distribution curves and for statistical analysis (see Table 5). They were first divided into male and female. The females included 145 controls from Yorkshire and 164 controls from Hertfordshire with 183 dope workers from Yorkshire, 174 from Hertfordshire, 44 from Surrey, and 193 rubber solvent workers from the London area and Portsmouth. The male group consisted of 38 controls from Yorkshire, 60 controls from a machine shop and 43 dope workers from Hertfordshire, 53 from Yorkshire, and 21 from Surrey. The haemoglobin was estimated, at the London Hospital, by a photo-electric cell after conversion to alkaline haematin; 100 per cent. is equivalent to 13·8 gm. of haemoglobin per 100 c.c. of blood. At the S.W. London Blood Transfusion Centre and in Yorkshire it was estimated by Haldane's method in accordance with a procedure laid down by the M.R.C. sub-committee on haemoglobin; 100 per cent. is equivalent to 14·8 gm. of haemoglobin per 100 c.c. of blood. In the case of the women, the frequency distribution curves for red cells, haemoglobin, total leucocytes and total polymorphs are similar in all the groups, and there is no difference of any statistical significance in the figures. Even before the war doping was usually regarded as a woman's occupation, and therefore the group of male workers is small, but they had usually been engaged on the work for more than twenty years. They complained of no symptoms, showed no abnormal physical signs, and scorned the idea that there could possibly be a hazard in doping. The frequency distribution curves for the red blood cells and haemoglobin showed no deviation and there was no difference of statistical significance between the figures. However, the curves for the total white cells and total polymorphs showed a shift to the left. The numbers of workers concerned are so small that it is not possible to derive from them any figures of statistical value.

From this material, therefore, it is not possible to arrive at any conclusion as to what early changes may be expected in the blood count from mild benzene intoxication, or to offer any advice or opinion as to whether leucopenia or relative lymphocytosis is a danger signal. No change was seen in any individual which could be attributed without doubt to benzene intoxication in a highly susceptible

TABLE 5

STATISTICAL ANALYSIS OF THE BLOOD INVESTIGATIONS IN WOMEN WORKERS

	No. in sample	Mean	Standard deviation	Difference between mean and mean of controls	Standard error
HAEMOGLOBIN.					
Hertfordshire controls	164	92·8	11·675	—	—
Hertfordshire dope workers ..	174	91·5	10·120	−1·3	1·19
Rubber solvent workers	193	94·4	9·735	+1·6	1·15
Yorkshire controls	177	89·5	10·450	—	—
Yorkshire dope workers	177	92·7	10·340	+3·2	1·11
Surrey dope workers	43	89·8	11·15	+0·3	0·95
RED CELLS.					
Hertfordshire controls	164	4·963	0·435	—	—
Hertfordshire dope workers ..	174	4·953	0·475	−0·010	0·048
Rubber solvent workers	193	5·078	0·403	+0·115	0·045
Yorkshire controls	172	4·85	0·369	—	—
Yorkshire dope workers	177	4·76	0·423	−0·09	0·424
Surrey dope workers	44	4·91	0·309	+0·06	0·538
WHITE CELLS.					
Hertfordshire controls	165	6·985	2·13	—	—
Hertfordshire dope workers ..	173	6·945	2·48	+0·04	0·25
Rubber solvent workers	192	7·285	2·42	+0·30	0·24
Yorkshire controls	123	8·836	2·99	—	—
Yorkshire dope workers	180	9·095	3·81	+0·259	0·37
Surrey dope workers	44	7·245	2·35	−1·591	0·41
POLYMORPHS.					
Hertfordshire controls	145	3·861	1·55	—	—
Hertfordshire dope workers ..	157	3·985	1·61	+0·124	0·182
Rubber solvent workers	182	4·176	1·61	+0·315	0·176
Yorkshire controls	14	4·638	1·75	—	—
Yorkshire dope workers	17	5·259	2·461	+0·621	0·755
Surrey dope workers	43	4·007	1·529	−0·631	0·872

person. This is not surprising since workers in the group examined were not exposed to concentrations of benzene in the atmosphere which would be expected to give rise to poisoning.

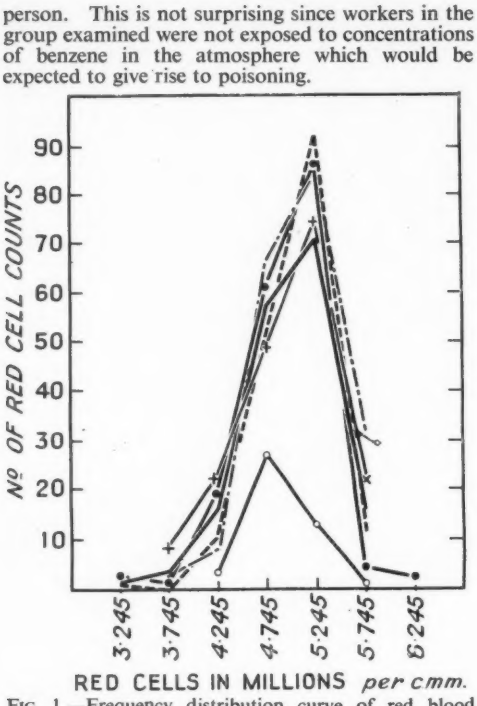

FIG. 1.—Frequency distribution curve of red blood cells in women.

See key on Figure 9. Hertfordshire controls (164); Dope workers (174). Rubber solvent workers (193). Yorkshire controls (H. J. B.) (172); Dope workers (177). Surrey dope workers (J. F. L.) (44)—line and circles.

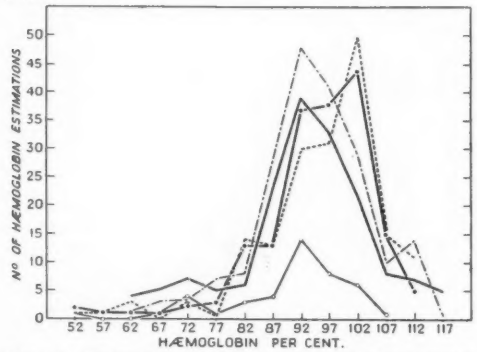

FIG. 2.—Frequency distribution curve of haemoglobin in women.

Hertfordshire controls (164); Dope workers (174). Rubber solvent workers (193). Yorkshire controls (177); Dope workers (177). Surrey dope workers (43)—line and circles.

Inorganic-Total Sulphate Ratio in Urine

This study of the effect of benzene on aircraft workers has also involved an investigation of the conjugated sulphate excretion in the urine of the workers. It has been shown by Schrenk, Yant and Sayers (1936) on experiments with dogs that benzene absorbed into the blood stream via the lungs is partly excreted in the urine as ethereal sulphate. This increase in conjugated sulphate occurs at the expense of the inorganic sulphate normally present, and so the percentage of inorganic sulphate of the total sulphate is diminished. This ratio is proposed as being a reliable index of the degree of benzene intoxication. A snap sample of urine is taken to carry out the test, since it concerns a ratio of one concentration to another, and not an absolute excretion of a particular substance.

This test was carried out on about 94 workers with rubber solvents, and 130 workers in dope shops (see Table 6). Comparative tests were made with 100 controls taken at random from hospital patients. The method used for the estimation was that of Milton (1932), and consists of the nephelometric estimation of a barium sulphate suspension, prepared under rigid conditions and in the presence of a protective colloid. Frequency distribution curves have been drawn and it is seen that the curves for the three groups are similar. The statistical analysis of the figures shows no difference of any significance.

In Yorkshire sulphate estimations were made on 178 dope workers and on 72 of the controls by the gravimetric method of Folin (1905) (Table 6). The

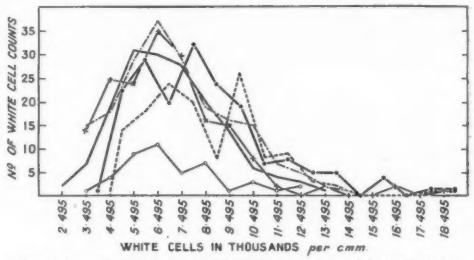

FIG. 3.—Frequency distribution curve of total white cells in women.

Hertfordshire controls (165); Dope workers (173). Rubber solvent workers (192). Yorkshire controls (123); Dope workers (180). Surrey dope workers (44)—line and circles.

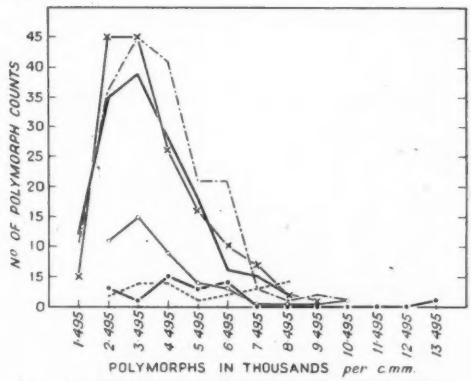

FIG. 4.—Frequency distribution curve of total polymorphs in women.

Hertfordshire controls (145); Dope workers (157). Rubber solvent workers (182). Yorkshire controls (14); Dope workers (17). Surrey dope workers (43)—line and circles.

specimens were collected in the afternoon so that any exposure to benzol in the morning might influence the sulphate ratio. The frequency distribution curve of these values is shown in Fig. 9; 12 of the dope workers had an inorganic sulphate ratio between 60 and 70 per cent. and 7 of these came from one factory. The remaining 5 were scattered throughout other factories. In general the distribution of sulphate ratios in the dope workers appears slightly lower than those in the control group, but as will be seen from the statistical analysis, there is no difference which is significant.

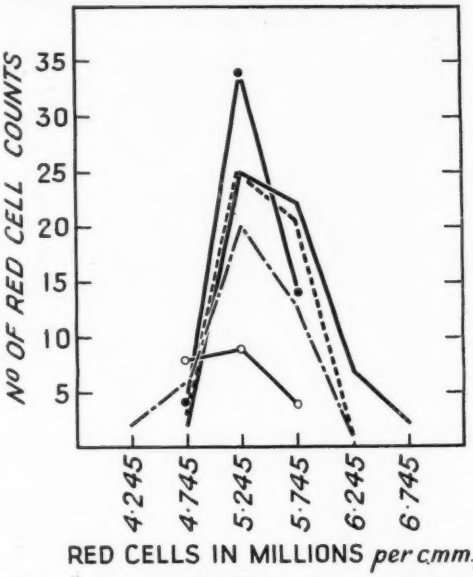

FIG. 5.—Frequency distribution curve of red blood cells in men.

Hertfordshire controls (58); Dope workers (42). Yorkshire controls (50); Dope workers (52). Surrey dope workers (21)—line and circles.

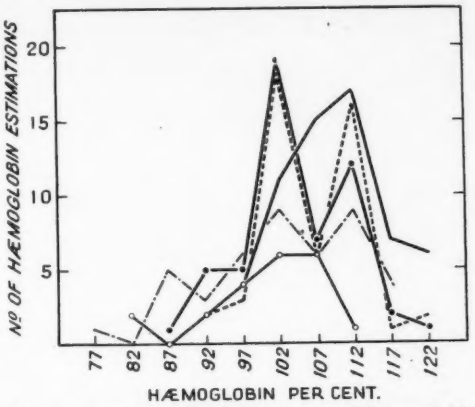

FIG. 6.—Frequency distribution curve of haemoglobin in men.

Hertfordshire controls (60); Dope workers (43). Yorkshire controls (50); Dope workers (52). Surrey dope workers (21)—line and circles.

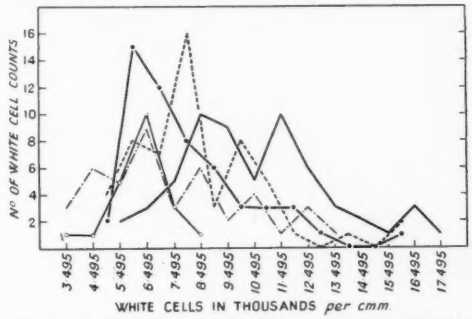

FIG. 7.—Frequency distribution curve of total white cells in men.

Hertfordshire controls (60); Dope workers (43). Yorkshire controls (54); Dope workers (54). Surrey dope workers (21)—line and circles.

TABLE 6.—INORGANIC-TOTAL SULPHATE RATIO IN URINE

	No. in sample	Per cent. total number of workers									
		100%*	95%	90%	85%	80%	75%	70%	65%	60%	55%
Hertfordshire controls	100	3·0	15·0	37·0	20·0	14·0	6·0	3·0	1·0	1·0	0·0
Hertfordshire dope workers ..	130	0·7	12·3	30·0	29·2	10·0	9·5	3·7	2·3	2·3	0·0
Rubber solvent workers	94	3·1	16·0	21·1	27·3	23·2	2·1	1·4	2·1	2·1	1·6
Yorkshire controls (H. J. B.) ..	72	10·0	11·2	33·3	16·5	16·5	5·5	7·0	0·0	—	-
Yorkshire dope workers (H. J. B.)	178	4·5	7·5	22·0	14·5	28·0	7·5	10·0	3·0	3·0	0·0

STATISTICAL EXAMINATION OF RESULTS

	No. in sample	Mean	Standard deviation	Difference between mean and mean of controls	Standard error
Hertfordshire controls	100	85·0	8·25	—	—
Hertfordshire dope workers	130	84·7	8·1	−0·3	1·07
Rubber solvent workers	94	85·2	8·43	+0·2	1·14
Yorkshire controls (H. J. B.)	72	85·5	8·17	—	—
Yorkshire dope workers (H. J. B.) ..	178	83·4	9·26	−1·1	1·19

* Inorganic sulphate as per cent. total sulphate (100%, 95%, 90%, etc.).

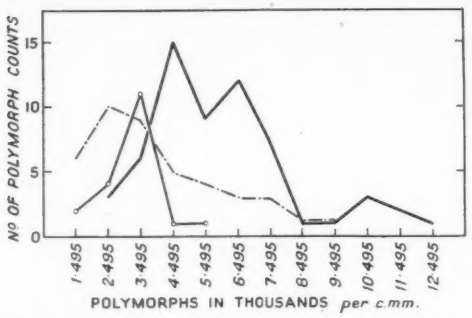

FIG. 8.—Frequency distribution curve of total polymorphs in men.

Hertfordshire controls (60); Dope workers (42). Surrey dope workers (19)—line and circles.

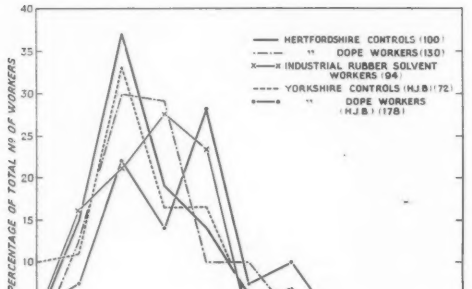

FIG. 9.—Frequency distribution curve of inorganic-total sulphate ratio in the urine.

Summary

In this investigation concentration of benzene in the atmosphere of dope shops and factories using rubber solvents did not approach toxic levels. Blood counts of workers in these factories were not significantly different from counts in a control group. No material change was found in the inorganic-total sulphate ratio in the urine of the workers. It is emphasized that, in the absence of estimations of atmosphere concentrations of benzene, blood changes alone cannot be accepted as evidence of benzene intoxication.

We are greatly indebted to Dr. D. R. Thompson, Miss Shervington and the De Havilland Aircraft Company, Ltd., without whose help the Hertfordshire part of this investigation could not have been carried out; to Dr. F. C. O. Valentine for help with this part of the haematological work; and to Dr. A. I. G. McLaughlin, H.M. Medical Inspector of Factories, and Mr. F. A. M. Vincent for their assistance with the Sheffield section of the investigation.

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DISEASE OF LUNGS IN BOILER SCALERS

WITH A CASE REPORT AND REVIEW OF THE LITERATURE

BY

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The tubes, flues and fireboxes of all steam boilers have to be cleaned periodically and during the cleaning process a good deal of dust is evolved. Ships' boilers are of two types, each of which consists of an arrangement of tubes in an enclosed space: (i) the original Scotch marine boiler in which the heat generated by the fuel passes through fire tubes surrounded by water which is converted into steam; and (ii) the water tube boiler in which, as its name implies, the water circulates in tubes surrounded by hot gases generated by the fuel. In the first type flue dust is found inside the fire tubes, and scale consisting of mineral salts deposited from the water is outside the tubes. In the second type the scale is inside and the flue dust outside the water tubes. In many modern boilers distilled and de-aerated water is used and therefore no scale is deposited in the water tubes. The tubes of water-tube boilers are usually scaled with an instrument fitted with rotating serrated or knurled rollers driven by air pressure and passed through the tubes. Scale is removed from the exterior surfaces of the fire tubes by means of a long pointed rod, called a slicing tool, and also by wire brushes. The flue dust in the fire tubes and fireboxes is removed by brushing.

The boiler scalers who in many cases work in confined spaces are liable to inhale two types of dust, (i) the scale deposited from the water circulating in or outside the tubes, and (ii) the dust in the fire tubes, flues or fireboxes. The distinction is of some importance because W. E. Cooke (1930) in his original paper entitled ' Pneumokoniosis due to flue dust,' showed that his sample of boiler scale contained much less silica than did the flue dust. In the samples analysed 6·4 per cent. of insoluble siliceous matter was found in the boiler scale, but in the flue dust there was 26·4 per cent. Cooke described the clinical and pathological features of a man of 35 years who had worked for 9½ years as a boiler cleaner and who developed chest symptoms with x-ray appearances suggestive of advanced silicosis. Autopsy revealed generalized patchy fibrosis in both lungs with tuberculous lesions in the right upper lobe. Chemical analysis of dried lung tissue showed a greater percentage than normal of insoluble and total silica. He was of the opinion that the fibrosis of the lung preceded the tuberculous infection by many years.

Williams (1931) described the clinical and x-ray findings in six boiler scalers, one of whom came to autopsy. In this case there was a diffuse ' anthracosis ' with relatively slight formation of fibrous tissue. Tubercle bacilli were found only on guinea-pig inoculation. Williams concluded that while the number of men examined was too small to make general inferences, the dust inhaled during boiler cleaning tended to encourage the development of pulmonary fibrosis. Dunner (1943) published a description of the clinical and radiographic appearances of 12 boiler scalers, all of whom had sought medical advice on account of chest symptoms such as pain and dyspnoea. Small haemoptyses occurred in two cases. The clinical picture resembled that of chronic bronchitis and emphysema. In no case were tubercle bacilli found in the sputum. The x-ray appearances were comparable with those illustrated in Williams' paper and were of three types. The first showed a uniform mottling over both lung fields resembling either ' chronic ' miliary tuberculosis or if the nodules were larger, the ' snowflake ' mottling of silicosis. The second type had, in addition to the uniform mottling found in the first group, larger irregular shadows due apparently to confluence of the individual foci. The third type showed ' a diffuse fibrosis.' In none of these cases were the radiographic changes correlated with histological studies of the lung nor were full occupational histories given. It might be remarked in passing that the range of x-ray appearances illustrated in the article showed a close resemblance to that described by Hart and Aslett (1942) in their studies of the pneumokonioses of South Wales coal miners. Todd and Rice (1944) gave clinical and x-ray details of a man 40 years of age who had worked in his early life for 14 years as a boiler scaler and who later developed shortness of breath. The radiograph showed a ' snowstorm ' type of infiltration of both lungs equal in intensity from the hila to the periphery of the lungs.

It will be seen that the subject of lung disease in boiler scalers has not yet had much attention and that up to the present time only two autopsies have been published. We think, therefore, that the following case of a boiler scaler in which clinical, radiographic and pathological studies have been made can usefully be recorded.

Case History

G.T., aet. 61 in 1943. He had been employed as a boiler scaler all his working life, from 14 years of age to within a few weeks of his death, that is, for 47 years. He had worked always on marine boilers. On 26.4.38 he was admitted to the Anlaby Road Hospital, Hull, complaining of cough, slight dyspnoea, slight sweating at night, expectoration, some loss of weight, and pain in the left side of his chest. He had had a cough for some years but his acute symptoms had begun 15 weeks before his admission to hospital. Pulmonary tuberculosis was suspected but there was no family history of the complaint. During his month's stay in hospital

he was found to be afebrile; no tubercle bacilli were found in the sputum on nine examinations and the erythrocyte sedimentation rate was normal. His weight increased from 8 st. to 8 st. 4 lb. Clinical examination of the chest revealed few abnormal signs except the presence of râles at both bases. X-ray examination (see fig. 1) at that time showed the presence of nodular shadows throughout both lungs more marked in the upper zones. The lower lung fields showed stippling and reticulation. These changes were first interpreted as being caused by broncho-pneumonic tuberculosis but later they were ascribed to the presence of pneumokoniosis ? silicosis. On 24.5.38 he was discharged from the hospital and went back to work.

On 20.12.43, 5½ years later, he was readmitted to hospital. On this occasion he had been ill for 5 weeks and had complained of pain in the left side of the chest with a cough which made the pain worse. His sputum was whitish, fairly copious and not blood-stained. He had rapidly lost a good deal of weight. On examination he was found to be emaciated, cyanosed and markedly short of breath on exertion. The percussion note was impaired over the right upper lung field and over the left base. Numerous moist sounds, coarse in quality, were heard over both these areas, more marked over the left base. At rest in bed the temperature fluctuated between 97° and 98° F., the pulse rate between 80 and 106 per minute, and the respiration rate between 24 and 28 per minute. The blood pressure was 120/84. A further x-ray film of the chest (see fig. 2) showed shadows similar to those seen in 1938, but in addition there was a ground-glass opacity involving the whole of the right upper lobe. A provisional diagnosis of pneumokoniosis complicated by carcinoma of the lung was made. His general condition rapidly deteriorated and he died on 29.12.43, that is nine days after his second admission to hospital.

Autopsy

An autopsy was made on 30.12.43. The body was extremely emaciated. There was slight clubbing of the fingers. In the line of the sixth left rib in the mid-axillary line a small hard mass could be felt.

Thorax.—Dense pleural adhesions were present on both sides, particularly over the upper lobes. About 1 inch of the right main bronchus showed a white, mottled, nodular appearance. When the rings of the bronchus were divided a firm carcinomatous growth was found to be invading the upper lobe of the right lung. Numerous secondary deposits were present in the mediastinum. Metastases were also present in the sixth left rib and in the seventh right rib just in front of its angle, in the muscle of the left ventricle near the apex of the heart, in the right lobe of the liver, in both kidneys and in the wall of the rectum. Further details about the pathological appearances of the lungs are given below.

The lymph nodes about the lesser curvature of the stomach were enlarged and pigmented. The stomach, spleen, gall bladder, skull and brain showed no abnormality. Apart from the secondary deposit in its muscle the heart was normal and the valves were healthy.

Laboratory Investigation

Right Lung.—There was a cream coloured growth in and around the uppermost main bronchus continuous with considerable tumour in the region of the hilar lymph nodes. The upper lobe was covered by thick, fibrous pleura, was heavy and almost entirely solid ; it sank in water. The cut surface of this lobe (see fig. 3) was marbled black and grey and had a hard rubbery toughness. The black nodules were shiny and varied in size up to ½ inch in diameter. Much of the intervening lung substance, particularly near the apex, was infiltrated with tumour: deep in the lobe were one or two small ragged cavities that did not suggest a tuberculous origin. The pleura of the middle and lower lobes was blue-black, shining and not evidently thickened. There was moderate emphysema with some small bullae at the anterior border: the cut surface was black with scattered nodules of two distinct kinds—(*a*) soft creamy nodules of tumour up to ¼ inch in diameter; (*b*) more numerous smaller hard black nodules. The emphysematous areas in the cut surface appeared more pigmented than the surrounding lung.

Left Lung.—The pleura was blue-black; there was some fibrous thickening over the apex and some fibrinous deposit at the base. The cut surface was black with numerous solid shining jet-black nodules especially in the upper lobe, in the lower portion of which some reached a diameter of ¼ inch. The lower lobe showed a moderate emphysema most marked along the anterior border; deeper in the lung the emphysematous areas were more pigmented than the surrounding lung. In both lobes were scattered nodules of tumour varying in size up to ¼ inch in diameter.

Other Organs.—Tumour was present in almost all of the available tissues: it was found in lymph nodes along the lower half of the trachea, around the hilum of the lung, and along the lesser curvature of the stomach. There were nodules of growth in the thyroid, heart, liver and kidney.

Microscopical Appearances.—In all its sites the tumour appeared as a partially differentiated squamous cell carcinoma. Sections of the upper lobes (see figs. 4 and 7) showed typical solid, collagenous, ' silicotic nodules ' that were as pigmented as those seen in the lungs of coal miners. A few such nodules were also found in the lower lobes (see figs. 5 and 6). Pigment was found in abundance also in all lobes, in the pleura, and in aggregates around pulmonary vessels and bronchi as well as in some phagocytic cells free in alveoli or contained in alveolar walls. The smallest of these aggregates closely resembled the reticulation described by Belt and Ferris (1942), but collagen fibrils were produced in increasing amount as the area grew larger. Many of the medium sized aggregates were rounded and markedly collagenous, but the collagen fibrils showed a tendency to be radial rather than to produce a whorl.

None of the pigment that was black and opaque stained with potassium ferro-cyanide and hydrochloric acid. Incinerated sections viewed by reflected light showed that perhaps a third of this pigment consisted of iron. This iron pigment occurred around the nodules of silicotic fibrosis but not within them; the pigment included in the nodules was presumably carbon since it disappeared on incineration. It has been our experience in this case and with many other lungs that it may be impossible in ordinary stained sections to distinguish between carbon pigment and some iron pigments. Incinerated and acid-treated sections viewed in polarized light showed silica particles as a fine dusting throughout the nodules and scattered in smaller amounts in the lung tissue. Although considerably more silica was visible than in normal lungs, there did not appear to be as much as we have often seen in other silicotic specimens.

The emphysema seen naked-eye was confirmed microscopically. No evidence of tuberculosis was found but there was an acute patchy pneumonia in the left upper lobe.

Chemical Findings.—Incinerated at 500° C., the previously dried lung yielded 5·1 per cent. tawny ash. Iron, reckoned as metal, formed 0·6 per cent. and silica 0·17 per cent. of the dry weight of the lungs. These figures relate to the lungs as a whole: presumably they would all be greater for the upper lobes alone, especially if tumour-free portions were chosen.

A sample of boiler scale taken from the type of ship's boiler usually scaled by this man contained 10·1 per cent. of iron calculated as metal, and 8·6 per cent. total silica probably present largely as silicate. A sample of flue dust contained 48·3 per cent. of iron and 6·1 per cent. total silica ; combustible material (soot) formed 27 per cent. of this dust.

Death resulted from wide-spread metastases of a squamous cell carcinoma of the bronchus. There was marked pneumokoniosis, with typical silicotic fibrosis particularly in the right upper lobe where it could be described as massive.

FIG. 2.—Radiograph of chest (29.12.43), showing ground-glass shadow in right upper region of the lung. Appearances in rest of lung fields comparable with those seen in Fig. 1. Note fracture of 7th right rib due to tumour metastasis.

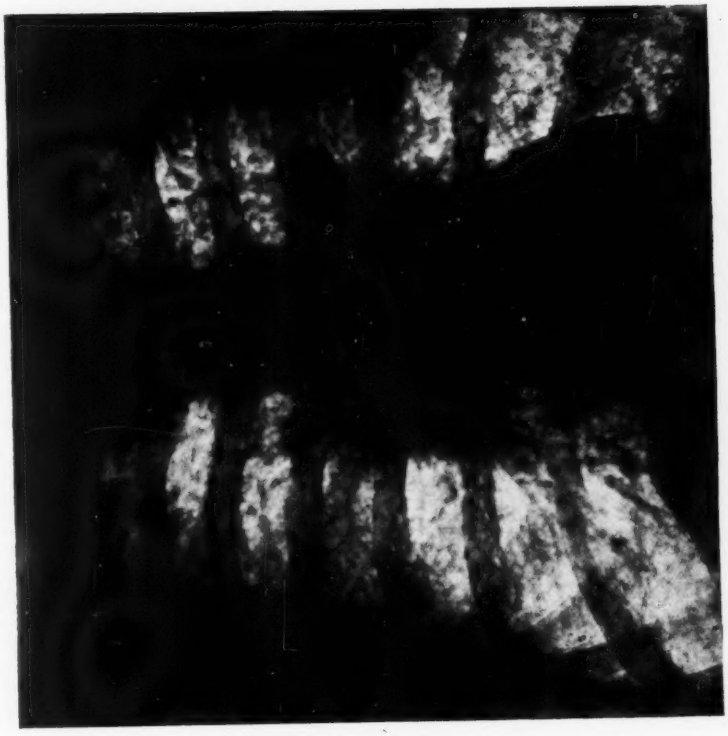

FIG. 1.—Radiograph of chest (28.4.38), showing nodulation in outer portions of upper lung fields and reticulation in the rest of the lung fields.

FIG. 3.—Photograph of slice of R. upper lobe × ½, showing bronchial carcinoma, pigmentation, nodules of silicotic fibrosis.

FIG. 4.—Photomicrograph, R. upper lobe, H. and E., × 4. Nodular fibrosis and pigmentation.

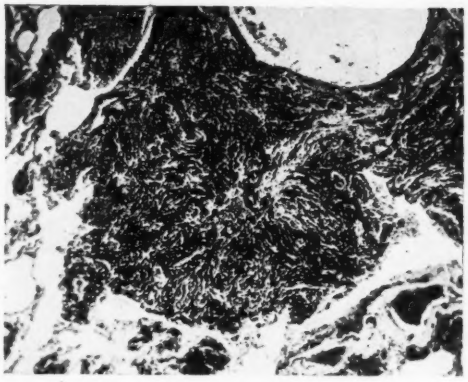

FIG. 5.—Photomicrograph, R. lower lobe, H. and E., × 32. Nodule of radial fibrosis and pigmentation.

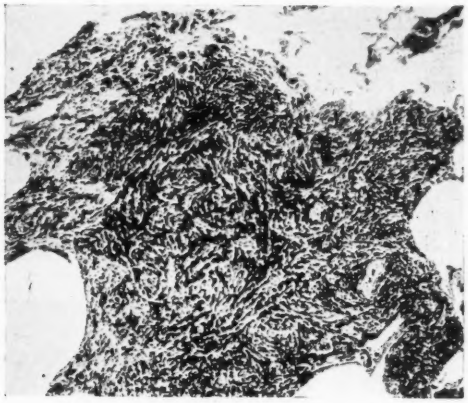

FIG. 6.—Photomicrograph, R. lower lobe, H. and E., × 32. Nodule showing early whorled fibrosis in centre with radiating fibrosis at periphery.

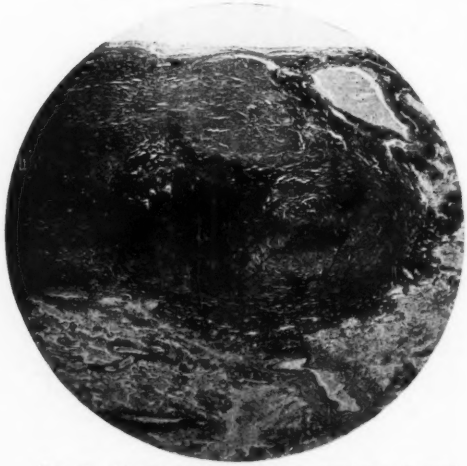

FIG. 7.—Photomicrograph, R. upper lobe. H. and E., × 12. Subpleural silicotic nodulation.

Discussion

Scalers or cleaners of ships' boilers are exposed to the inhalation of dusts of variable composition. The boiler scale varies according to the hardness or other impurities in the water used in the boilers and the composition of the flue dust varies with the type of fuel used, e.g. coal or oil. This variation can be seen by comparing the analyses of Cooke's samples of boiler scale and flue dust with those of our samples:—

	Boiler scale	*Flue dust*
Cooke's samples		
Total silica ..	10·3 per cent.	32·4 per cent.
Iron (oxide) ..	3·42 „ „	27·17 „ „
Our samples		
Total silica ..	8·6 per cent.	6·1 per cent.
Iron (metal) ..	10·1 „ „	48·3 „ „

We have selected silica and iron for comparison, because these two substances in dust form probably have most effect in producing abnormal appearances in the x-ray films of boiler scalers' lungs. The dust of free silica (SiO_2) when inhaled by workers in fairly high concentrations over a period of years produces silicosis with characteristic x-ray and pathological appearances. These may be modified if the dust of free silica is mixed with other dusts. Abestosis, another form of pneumokoniosis, can be set up by the inhalation of the dust of abestos which is a silicate or combined silica. Aggregates of iron dust in the lung tissues are opaque to x-rays. Studies of the effects of iron on the lungs [McLaughlin, Grout, Barrie and Harding (1944); Enzer and Sander (1938); Sander (1944)] have shown that iron oxide in its pure form does not set up a fibrotic reaction in the lung tissues, but that aggregates of it cause abnormal x-ray shadows which are difficult to distinguish from those thrown by early silicotic nodules, other pneumokonioses or miliary tuberculosis. It is probable that many of the abnormal x-ray shadows in our case, particularly in the lower lung fields, were caused by iron deposits in the lungs, and were not due to fibrosis. It is noteworthy that the flue dust contained as much as 48·3 per cent. of iron (the boiler scale containing 10·1 per cent.) and that the dried lung contained 0·6 per cent. of iron as compared with 0·17 per cent. of silica. In our experience the x-ray shadows thrown by iron deposits do not become confluent, i.e. they do not advance much beyond the stage of reticulation. Examination of the x-ray film (fig. 1) shows that the nodulation and early massive shadows are confined to the upper halves of the lung fields, whereas the lower lung fields show reticulation. The histological studies of sections of the lungs more or less confirm that the nodular shadows mainly correspond to silicotic nodules, and that many of the reticular shadows are thrown by iron aggregates in the lung tissues (see fig. 8). Some of the latter are no doubt also due to early silicotic fibrosis (see figs. 5 and 6).

It is possible that the carcinoma from which the man died was initiated by a carcinogenic agent in the flue dust or soot. This point is being further investigated.

FIG. 8.—Photomicrograph, R. lower lobe, H. and E., × 40. Pigmentation without fibrosis around vessels.

Summary

(1) The clinical, radiographical and pathological features of the lungs of a boiler scaler are described. Short notes are given of the processes in the scaling of marine boilers. Analyses of the silica and iron contents of the lungs are recorded and also of samples of boiler scale and flue dust.

(2) Well-marked silicosis was found in the lungs, together with marked pigmentation due to iron. Death was due to dissemination of tumour from a carcinoma of the bronchus.

(3) It is suggested that the abnormal shadows seen in the x-ray films of boiler scalers' chests are due partly to areas of silicotic fibrosis and partly to deposits of iron dust which is opaque to x-rays.

Acknowledgments

We are indebted to Dr. Nicolas Gebbie, Medical Officer of Health for Hull, for permission to report the case; to Dr. L. C. D. Hermitte and Mr. G. S. English for figs. 3 and 7; to Mr. A. W. Collins for figs. 4, 5, 6 and 8; and to Mr. J. MacColl for much help on the industrial aspects of the investigation.

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LONDON, October, 1944

SICKNESS RECORDS IN INDUSTRY

Sickness records are essential to determine the effect upon health of environmental conditions at the place of work; and a uniform or standard recording method, common to all industries, is necessary for scientific comparative purposes. A recent report from the Industrial Health Research Board [1] stresses these two points in the following introductory paragraph:—

> 'Before the war, many of the more enlightened organizations in this country adopted their own methods for recording sickness absence. They realized that such records would not only help them to determine the effective labour strength, as opposed to the book strength, of their staffs, but would also enable them to keep a check on the effects of conditions of work on the health of those employed in the various departments of the factory, shop, or office. The methods adopted were, however, evolved separately in each firm, and could not be used for comparing the sickness rates of different firms. They lacked the uniformity which is essential for valid statistical comparison.'

The recording and analysis of sickness absence in industry provides information about the health of the individual which can be used for determining fitness for different forms of work. It yields knowledge of the health of groups of workers and affords a basis of comparison between department and department in the same organization, between firm and firm in the same industry, or between one industry and another. Thus in time we may gain more exact information about morbidity, as apart from mortality—the specific study of the Registrar-General—among the 18 million persons working in British industry.[2] The value of remedial and preventive measures in reducing the incidence of ill-health can be assessed by such systematic and standard recording of sickness absence, and out of this will come, too, valuable data and incentives for research. Records of total absenteeism—including not only absence on account of ill-health and accidents but for other causes, with or without reasonable excuse—have been collected by industry since 1939. This may be because managements need accurate day-to-day knowledge of their man-power position in relation to Government contracts, and because absence from work without reasonable excuse is a direct offence against the law under the Essential Work Order. But the proportion of absenteeism directly accounted for by sickness of different kinds—and for recording purposes the report includes accidents under the same heading—is still largely a matter for conjecture. And so we welcome this attempt by the Board to find a solution of what is undoubtedly a complex problem.

For the practising industrial medical officer the report is one of the most important the Board has issued and is the work of a special sub-committee under the chairmanship of Dr. A. J. Amor. It makes four main points: the keeping of records is essential if absence due to sickness is to be properly estimated and controlled; the method of obtaining initial information depends on the size, distribution, and organization of the industry concerned; the value of records depends on their accuracy, and on the use of a standard recording method; and, finally, certified sickness absence should be classified, as far as possible, into groups of diseases which may be related to the working environment. The size and importance of any industrial health problem must be fully assessed before control is applied: the expenditure of money on health measures in industry must be determined by economic as well as by humanitarian considerations, with industry as it is at present. In the past control of a so-called health hazard has sometimes been attempted before its significance has been completely grasped, and this has been responsible for wasteful effort. For example the term 'industrial rheumatism' is not infrequently used to denote some alleged occupational factors in aetiology. But is the extent to which it occurs in different industries and occupations known? Are those who use the term satisfied they have eliminated the many non-industrial factors that influence its incidence and severity? Has an attempt been made to subdivide rheumatism into its common groups in relation to occupation, age, sex, or duration of employment? Without accurate information on the incidence of rheumatism (or of any other common disease) in the various occupational groups we cannot even attempt to analyse industrial factors in causation.

The second point made in the report—the difficulty of obtaining a daily list of absentees and those returning to work—brings to the fore a practical issue which varies with the size of the organization and its distribution: for example, a firm may be dispersed into small units, or have a number of constituent companies in different parts of the country. In the case of large firms with a clock-card system unclaimed cards can be removed and others of a different colour substituted; the head of a sizable department can keep his own register of absentees; the foreman of smaller groups can fill in a card; or, if necessary, some other responsible person can be deputed to compile the daily list. On confronting his management with a scheme such as is proposed the industrial medical officer will certainly be asked the question: 'How much is this going to cost?' The report attempts to answer this in an appendix. In a factory with a population of over 4000 and already keeping records of total absence it is estimated that an additional £400 a year to meet the cost of three additional clerks is necessary. In smaller factories—and these constitute the bulk of industry—the

[1] *The Recording of Sickness Absence in Industry* (1944). I.H.R.B Report. No. 85. H.M.S.O. Lond.

[2] The estimated number of "employed persons" under peace-time conditions is 13½ million men and 4¾ million women. *Social Insurance, Part I*, 1944. H.M.S.O. Lond.; p. 48.

cost will be correspondingly less. More information on this point will be of value. The usefulness of records depends, as the report goes on to state, on their accuracy and on the use of a standard measure. We would emphasize, too, the need for constant analysis so that the reasons for sickness absence and preventive measures may be continually reviewed. Accuracy will depend largely on the skill of the person responsible for compilation, and with an intelligent person the extent of error should not be great. There is a risk, however, that in some cases the matter will be handled by a junior clerk insufficiently qualified.

The institution of a standard measure common to all industry is the main thesis of the report. The committee recommends the use of an individual record card (Form II), or, as an alternative, a register or nominal roll of sickness absence (Form III). In addition to the usual information such as name, check number and occupation, and the reason for absence, the individual card summarizes absences under two headings: long absence of 4 consecutive working days or more, and short absence of less than 4 consecutive working days but not including absences of under one day. From the original information provided by the department, shop, or other convenient unit, information is filled in daily. The card is designed to deal with the history of a case over two years, a convenient way of seeing the record at a glance. The sickness absence return (Form IV) gives a monthly summary of the position. Quarterly or yearly summaries are similarly compiled. The following measurements are recommended: (1) average number of days lost per worker per month, and from that per quarter or per annum; (2) percentage loss of planned production time; and (3) percentage of workers who have not been absent through sickness. But when we come to the classification of sickness in industry and its relation to working conditions the problem becomes less easy. The report suggests it is safer to classify certified sickness only, and seven classes are proposed (Form V): influenza and colds, respiratory disease, digestive disease, rheumatism, functional nervous disorders, accidents at work, and unclassified conditions. These classes are recommended because they 'may have some relation to the industrial environment.' While this may be admitted there is still the question of accurate diagnosis. For many reasons National Health Insurance certificates are not necessarily accurate, and even the grouping suggested leaves plenty of room for error. But medical officers in industry may feel that some classification is necessary in the hope, as the report says, that this 'will make it possible to detect unusually high rates of sickness in certain groups of illnesses.'

The implications of such a scheme as this are interesting. If it is to be really effective it must develop on a comprehensive or national basis. Only thus is it possible to compare the health, and therefore possibly the occupational factors affecting health, of quarrymen in Buxton with that of railway porters at Euston, or dockers at Manchester with workers in the engineering trades of Coventry. And a possible clue to causation having been obtained, preventive and remedial measures must be sought and research initiated. Thus social biology can be linked with industrial medicine. One other implication needs comment. What machinery is necessary to analyse the vast amount of data which will come from factories, mines, docks or commercial undertakings, in urban areas and rural districts; from different trades and occupations in these industries; or from different age groups? Suppose, for example, that it was compulsory to report all sickness absence over 3 days—as the reporting of accidents causing loss of more than 3 days from work is now a statutory obligation—to whom should the report be made? And what use could be made of the figures? This is the challenge, by implication, of the report. The Industrial Health Research Board itself is not constituted for this work; nor is the Factory Department of the Ministry of Labour, because it deals only with factories. In the development of a national industrial health service statistics must play a large part, and in any central and regional organization which may be set up the compilation and analysis of morbidity figures from industrial undertakings must eventually be the responsibility of a properly organized statistical department.

It is easy to criticize any attempt to lay down a standard method of recording sick absence; different industrial medical officers may have widely differing views concerning the best method. This is the first time that anything so ambitious, along these lines, has been attempted in this country—or as far as we can determine, in any other country. The committee is to be congratulated on its efforts. Wisely its report has been labelled 'preliminary,' for in the light of experience some of its recommendations may have to be amended. It is now surely for industry to test the scheme through its labour, welfare, medical and nursing personnel, even if it means altering present methods. Many firms, among them some of the largest in the country, have been waiting a lead in this matter. We hope, therefore, that the methods suggested will be given the widest possible trial.

BENZENE

Benzene, or benzole, is a hydrocarbon of the aromatic series and a coal tar product. It is clear colourless liquid with a characteristic smell. It must not be confused with benzine, which is a distillate of petroleum. Benzene has two distinct fields of use in industry.[1] Firstly, where it is handled in large quantities in closed systems, such as the distillation of coal and coal-tar and the blending of motor fuels; in the chemical industries it has wide application in oil extraction, organic intermediates for dyes and drugs, manufacture of paints, varnishes and stains, and of paint and varnish removers. Secondly, it is used as a solvent in the rubber industry; in solutions for 'rubber cement,' in the manufacture of straw hats, cardboard boxes, waterproof goods, shoes, cameras, the sealing of cans, and the rubber tyre industry; in the artificial leather industry; in the dyeing and cleaning industry; in the paint and varnish industry; in the aviation industry as a constituent of 'dope'; in the linoleum and celluloid industries; in artificial manure and glue manufacture; in electrical fitting and accumulator works; in chemical laboratories and in the alkaloid industries.

Benzene poisoning has been very carefully controlled in Great Britain by the Factory Department

[1] Browning, E. (1937). *Toxicity of Industrial Organic Solvents*, I.H.R.B. Rep. No. 80. H.M.S.O. Lond.

of the Ministry of Labour, so there has been little opportunity for investigation of this problem. Special legislative requirements regarding ventilation of shops where benzene is used are laid down;[2 3] and there is an important general requirement, in the same connexion in Section 47 of the Factories Act, 1937. Legislation may also demand frequent examination of employees by the Examining Surgeon. Chronic benzene poisoning is notifiable as such and as toxic anaemia, so the chances of a case escaping notice are small. These protective arrangements are so satisfactory that in the ten years preceding the war only nine cases of chronic benzene poisoning were notified.

Santesson [4] and later Selling [5] established the conception that benzene produced a toxic effect on the bone marrow, first destroying the platelets, then the granular leucocytes and finally producing the complete picture of aplastic anaemia. Recently, however, lagely owing to the work of F. T. Hunter,[6] it has been realized that the blood picture may vary from severe hypoplasia to the most extreme hyperplasia and even leukaemia. Hyperplastic reactions are more common in males and are found in patients only after prolonged exposure; hypoplasia, on the other hand, is more common in females and may follow either short or long absorption. These pleomorphic manifestations due to chronic benzene poisoning are similar to those caused by other toxic substances and described by Bomford and Rhoads [7] as refractory anaemia and by Evans and Perry [8] in an account of thrombocytopaenic purpura. It is important to establish what are the first signs of benzene poisoning. They are probably varied. There is every reason to expect that the manifestations in a group of rotogravure workers of mixed European descent working in a New York cellar with atmosphere concentrations up to 1000 parts per million as described by Greenburg and his colleagues [9] would be entirely different from those in a group of Yorkshire girls working in a dope shop.

The outbreak of war, with the huge demand for aircraft and diversion of toluene to the manufacture of explosives, necessitated a slight relaxation of the high standard of protection from benzene. As a result, anxiety was felt that some of the dope girls might be showing signs of intoxication and it was also thought that there might be an opportunity for investigating the early signs of chronic benzene poisoning. D. Hunter and colleagues seized this opportunity and we publish the results of their investigations in this number of the JOURNAL. They were unable to detect any significant changes in the blood or any change in the inorganic total sulphate ratio in the urine of the groups of workers examined. Much work in the past has attributed leucopenia in such groups of workers to benzene poisoning, but this latest investigation shows that there is no justification for doing this unless it is proved that the workers were in fact exposed to a toxic concentration of benzene in the atmosphere. In the dope shops examined it was found that the concentration in the general shop rarely rose above 10 parts per million; and even on such specialized jobs as spraying the insides of cockpits the concentration rose only to 45 parts per million and then only for short periods of time. The toxic level for benzene in the atmosphere is usually stated to be 70–100 parts per million; but when the possibility of idiosyncrasy is considered the only level which can be regarded as safe is zero. Hunter and his colleagues at the same time investigated the conditions in workshops where rubber solvents were used—these are made to Ministry of Aircraft Production specification and contain 5 per cent. of benzene, but the atmosphere concentrations of benzene in these shops was never higher than two parts per million. Hamilton-Paterson and Browning [10] reported a leucopenia arising in similar workshops, but all the evidence is that the cause of this phenomenon must be sought elsewhere than with benzene. Later, Hunter and his colleagues estimated the benzene concentrations in factories making artificial leather and here they found the concentrations in the general shop between 20 and 30 parts per million. These are not toxic levels and therefore will not give rise to symptoms.

The situation with regard to benzene in Great Britain during this war may therefore be looked upon with satisfaction and pride. It is most unlikely that any dope girl has been poisoned with this substance; and it is difficult to find anybody who has been exposed to toxic levels. Though it is unfortunate from a scientific point of view that it is not possible to investigate the early signs of poisoning, the Factory Department are to be congratulated on the way in which they have protected the worker from this hazard.

[2] *The Cellulose Solutions Regulations* (1944). S.R.O., 990.
[3] *The Indiarubber Regulations* (1922). S.R.O., 329.
[4] Santesson, C. G. (1897). *Arch. Hyg.*, **31**, 336.
[5] Selling, L. (1910). *Bull. Johns Hopk. Hosp.*, **21**, 33; and (1916). *Johns Hopk. Hosp. Rep.*, **17**, 83.
[6] Hunter, F. T. (1939). *J. industr. Hyg.*, **21**, 331.
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[8] Evans, H., and Perry, K. M. A. (1943). *Lancet*, **2**, 410.
[9] Greenburg, L., Mayers, M. R., Goldwater, L., and Smith, A. R. (1939). *J. industr. Hyg.*, **21**, 395.
[10] Hamilton-Paterson, J. L., and Browning, E. (1944). *Brit. med J.*, **1**, 349.

REVIEWS

ESSENTIALS OF INDUSTRIAL HEALTH

By E. O. Sappington, M.D., Dr.P.H.

(Lippincott Company, Philadelphia and London. 1943. Pp. 626. Illustrated. 42*s*.)

Very few books on industrial medicine have been published in this country, so this new volume will prove useful as a book of reference for the established medical officer and a helpful guide to those new to industry. While the subject matter is culled from American experience the figures quoted and the views expressed may stimulate industrial medical officers in this country to investigate many of their own problems in a similar manner to that adopted in the U.S.A. Although we were pioneers in the improvement of industrial working conditions, and much American legislation has been based on the experience of our Factory Department, descriptions of the type of industrial medical service of many American companies suggest that on some points they have outstripped us. The author takes the realistic view that industrial health service pays handsomely and gives figures to support this.

The book is divided into three main parts. Part one, on industrial health administration, covers the history of industrial medicine, occupational morbidity and mortality. The scope and objectives of industrial health, the type of knowledge required by the industrial medical officer, and the organization of medical services for small and large factories are given in detail. Part two, on industrial hygiene and toxicology, is valuable in that it classifies the various types of industrial health exposure, giving lists of materials and circumstances likely to affect health with a description of the clinical picture and the trades in which such dangers are encountered. The way to survey plants with simple methods of sampling and analysis should prove helpful in controlling and maintaining control of working conditions. Planned sanitation and hygiene for workers including co-ordination of industrial and community health services are described in detail. Part three deals with industrial medicine and traumatic surgery and covers methods of co-ordinating the worker's physical and mental make-up with the job he has to do. Causes of industrial accidents and occupational disease are estimated and their control and treatment described. The importance of prevention is the keynote of this book. The author at every stage stresses the value of keeping adequate records and, what is far more important, the use to which such records can be put.

W. E. C.

A GUIDE FOR THE TUBERCULOUS PATIENT

By G. S. Erwin, M.D.

(William Heinemann, London. 1944. Pp. 112. 3*s*. 6*d*.)

Dr. Erwin has fulfilled a great need by supplying this useful book for the tuberculous patient. It explains in simple language the nature of the disease and the conditions which are necessary for its successful treatment. To do this is a most important part of the treatment of any chronic disease which does not completely incapacitate the patient. It is specially important at the present time when, rightly, attention is focussed on the employment of the disabled. Pulmonary tuberculosis incapacitates more people in the prime of their working life than any other disease. On choice of work, however, Dr. Erwin states that 'individual advice should be sought from the sanatorium medical officer.' These doctors can certainly advise on the patient's response to work and exercise but probably have had little experience of work in most industries. It is certain that consultation between the industrial medical officer and the sanatorium medical officer would result in better advice than could be given by either alone. On the subject of food in the sanatorium, Dr. Erwin implies that there is often complaint and suggests that the patient is at fault. Food can, and should be, served well and attractively to the sick, but one fears that in many public institutions this is not done. Surely, therefore, rather than condemn the patient it would be better to stimulate a movement to provide appetizing food in such places. The book achieves its object and can be recommended to those for whom it is written. There must be many working in industry who would be glad to know that it has been published.

K. M. A. P.

THE JOURNEY TO WORK

By K. Liepmann, Ph.D.

(International Library of Sociology and Social Reconstruction. Kegan Paul, Trench, Trubner and Co. London. 1944. Pp. 204. 15*s*.)

'Travelling . . . ' states the Barlow Report (p. 91)' 'can hardly fail to have adverse effects on health and to result in fatigue (and) loss of energy. . . . There can be little doubt, too, that these adverse effects on the workers are reflected in no small measure on their efficiency and output and in turn, on the employers' cost of production.' Industrial medical officers will agree with these words quoted by Dr. Liepmann, but will understand her comment that this statement is founded on a general impression and not on exact knowledge as there have been previously no special investigations published on the subject. There are certain benefits to the worker resulting from an ability to travel to his job, says the author; it 'helps him in getting the right job, in retaining a suitable job, in combining two intermittent (seasonal) jobs and in changing over from declining to flourishing industries,' and in 'the prevention of frequent migration of individuals and families. The worker's family as a whole benefits from the varied employment of its members and domestic life is enriched by a variety of occupational interests among the family.' It is also true, however, as Mr. Carr Saunders says in his admirable preface, that 'less attention is perhaps paid to the positive evils arising from daily travel. It is not merely that time is wasted, it is not just that so many hours are lost from the day. To many daily travel is a cause of nervous fatigue; the zest of a new day is worn off before it has begun. More than that, no faculty can be properly exercised while travelling in crowds, it is difficult to read, to observe, to concentrate or to contemplate with any profit. The necessity of passing so much time each day during which profitable activity is difficult or impossible encourages the habit of passing all leisure time in this way. The daily journey to work is one of the features of modern life making for depersonalisation and accounts in some degree for the inability of men nowadays to enjoy themselves in creative activity or, indeed, in any fashion which demands more than passive response.'

Valuable charts are given showing in scale maps the residential distribution of employees of representative London and Birmingham factories.

Turning to the wider problems surveyed in this book Dr. Liepmann deals at length with the present problems

of and implications for town planning which have resulted from the lack of co-operation between housing and other authorities. In London, for example, workers have to travel from Becontree to the new factories on the Great West Road. The policy of open development of the suburbs—an endeavour to house the urban population in rural surroundings—is shown clearly to have resulted in the unwieldiness of large cities, the lack of a feeling of community such as would more easily arise in the recommended compactness of building, and in increasing the distance to be travelled each day. Many suggestions are made as to remedies, but one which commends itself is the suggestion that 'communal leisure facilities and decentralized services should be supplemented by making the residential districts areas of local government.' Another important requirement of this wider issue is to foster citizenship also at work places. Society cannot afford to neglect the work places as potential foci of common interest and local affinity. 'If accompanied by a proper organization of social and civic life,' Dr. Liepmann concludes, 'the severance of dwelling-place and work place (as is now increasingly seen) may well prove to be for the benefit of the urban population.'

The second half of the book contains the results of statistical inquiries and includes the U.S.A. and German industrial centres. The whole book is of significance to those concerned with transport, town planning and industrial health. J. G. B.

A STUDY OF VARIATIONS IN OUTPUT

Emergency Report No. 5 of the Industrial Health Research Board

By S. Wyatt, D.Sc.

(Assisted by R. Marriott, B.Sc., W. M. Dawson, B.Sc., D. E. R. Hughes, and F. G. L. Stock)

(H.M. Stationery Office. 1944. Pp. 16. 4*d*.)

It is widely held that, for economic reasons alone, the working week should be reduced below 60–65 hours for men or 55–60 hour for women—the so-called maximum levels for manual work involving medium physical effort. So an investigation was planned to prove the truth of this belief.

At the end of 1942 the weekly hours of work were reduced in certain factories; these were selected for this study. Although the reduction varied in different factories it was thought that the change in hours of work might have a measurable effect on output. It was therefore interesting to find that the most striking feature of the output records was their variability. Although stable operations were chosen for measurement there was often considerable weekly fluctuation. The chief causes of this were changes in the type of design of production, mechanical defects or breakdowns, variations in quantity or quality, progressive improvements in the methods of work, changes in the lay-out of machines, and personal factors such as dissatisfaction with wages or friction between management and workers. These points are of interest to the future investigator, and show some of the real difficulties in carrying out a scientific study of a problem such as this.

Despite the presence of these interfering factors, however, the hourly output increased in 15 out of 21 groups during the period covered. The average increase for all the factory groups was 4·1 per cent. but in some it ranged from 11 to 21 per cent. This satisfactory feature of the results was due mainly to small but progressive improvements in methods and conditions of work, but in some groups it was accelerated by fairly large-scale measures of reorganization. Although the effects of shorter hours of work were, in most groups, mainly obscured by the presence of other factors there is reason to believe that the effects were favourable. Thus in three groups free from disturbing influences the period after the reduction of hours showed an increase in hourly output of 3·3–6·3 per cent. In most groups the shorter working week was appreciated by the workers, especially by women with family and home responsibilities. In some groups there was a slight decrease in absenteeism. In general the trend of output was upwards despite the shorter hours of work. A comparison of the amount of absence in the different factories showed, on an average, that it was appreciably higher among two groups of women employed on a 3-shift system than among 5 groups of women on a 2-shift system. There was also a tendency for absence among men and women on a 2-shift system to decrease as the weekly hours of work decreased. On the 2-shift system there was little difference between hourly output during night and day work. On the 3-shift system output was likely to be highest on the afternoon shift and lowest on the morning shift.

The Board rightly states that it is unjustifiable to make dogmatic statements about the results obtained which, incidently, corroborate previous work by Sargant Florence and others. But the fact that the investigation has been carried out, and has clearly shown the type of difficulty that can and will arise in similar studies, is justification for starting it. A wide field for research is thus again opened up.

D. S.

OCCUPATION AND HEALTH. SPECIAL SUPPLEMENT—INDUSTRIAL HEALTH IN WAR TIME

(International Labour Office, Montreal. 1944. Pp. 39.)

The International Labour Office has recently published a Special Supplement to its Encyclopaedia of Hygiene, Pathology, and Social Welfare. This deals with many aspects of industrial health as it is affected by war-time conditions in Great Britain, the U.S.A., the U.S.S.R., France, Germany, and other countries. Employment of large numbers of persons with no previous experience of industry, the necessity for work at high pressure, 'black-out' regulations, and the relaxation of many rules controlling health and safety, together with the handling of many noxious substances—some of which are new and imperfectly understood—have combined with difficulties in housing, transportation, and food so as to lead to much illness and loss of efficiency. Study and research in these matters have engaged the attention of those countries concerned, but exchange of information has been hindered by security considerations—many war-time processes are secret—and by difficulties in holding conferences and publishing reports.

In view of these conditions the present Supplement is of particular value; it gives, in the small compass of 39 pages, a summary of the principal observations made during the past four years in the fields of industrial hygiene and toxicology. This includes dust diseases; poisoning by lead, magnesium, mercury, and other metals; carbon monoxide; explosives; solvents; rubber substitutes—synthetic rubber has been produced in large quantities in Germany, the U.S.A., and, since 1935, in the U.S.S.R.; chlorinated naphthalenes; radio-active substances; and notes on caisson disease, aviation hygiene, and skin affections. References to recent literature on these subjects are given. D. C. N.

ABSTRACTS

Health of the Factory Worker in Wartime. Second Milroy Lecture.* HENRY, S. A. (1943). Fact. Dept. M. of L., H.M.S.O., Lond.

During the war labour has been directed to factories by order of the Minister of Labour. There has also been 'dilution' of skilled workers and introduction of part-time labour. There is no legal limit to the hours of work for men, but the Ministry controls hours for women and young persons. Varying forms of shift work for women were devised, but women have proved capable of much work hitherto done by men. During the last war there was a significant increase in anthrax, with a mortality rate of over 13 per cent., infected wool causing 56 per cent. of all cases. In this war there has been no such increase; the mortality rate has been 11·6 per cent., wool being responsible for 35 per cent. of cases. Phosphorus poisoning is practically non-existent, one case being reported in 1941. The number of cases of lead poisoning has decreased; in 1941 only 59 cases were reported, the lowest ever recorded. Methods of defence against absorption of toxic materials can be seen at the Home Office Industrial Museum, Horseferry Road, London, S.W.1. There has been a great advance in propaganda—by poster and pamphlet—as a means of health education. The Factories (Canteen) Order, 1940, has played a part in maintaining physical health. Nearly 11,000 'premises' under the Factories Act now have canteens. Distribution of synthetic vitamins in factories is unscientific and is discouraged. Welfare matters *outside* the factory have been studied. Provisions are made for 'transferred' workers; billets are found; sick bay accommodation is provided. 'Shopping time' is encouraged. Day nurseries have been set up. Recreation clubs and entertainment by E.N.S.A. and the B.B.C. have proved of much value.

The author stresses the need for research. The chemist plays an important part in this. Statistical evidence in regard to the relationship of mortality to occupation is provided by the staff of the Registrar-General. Specialised long-term research is in the care of the Medical Research Council and the Department of Scientific and Industrial Research. Training of doctors, nurses, and welfare officers is important, and different short-term courses are available in London and the provinces. Some persons have visualised an industrial centre or institute, which might well form the nucleus for post-graduate training and provide a museum, a library, a journal, and facilities for research. This might culminate in a Diploma of Industrial Medicine. D. S.

Night Sanatoria in the U.S.S.R. A. GULYAYEV (1944). Compiled from material supplied by VOKS, Moscow, by courtesy of the Anglo-Soviet Medical Committee.

During the arduous autumn days of 1942 it was suggested that night sanatoria should be established to improve the health of factory workers, to enhance their efficiency, and thereby to raise production. This plan was supported by the People's Commissariat of Health and many such sanatoria have now been established. A typical example is provided by an aircraft factory attached to which there is a sanatorium to accommodate 70 persons. It is financed by the Aviation Workers' Union from its Social Insurance funds. The food comes mainly from the local city Department of Health, which also supervises the medical arrangements. The factory administration provides the buildings and equipment, and contributes some food from its own farm. The worker pays nothing for his maintenance, but hands over his ration cards.

As in other such sanatoria, this establishment provides for workers suffering from any form of physical debility who may need extra diet and rest under medical supervision. The results are seen in a striking improvement in health and output. A chart kept by the medical director, Dr. Yakov Belenky, shows that among a group of workers using the sanatorium for three months there was an average gain in weight of 1–2 kilograms, and a rise of from 5 to 15 per cent. in haemoglobin. Records of three of these workers show that their output had more than doubled, despite the fact that their working day, during their stay in the sanatorium, had been shortened by three hours.

Workers attending the sanatorium cease work at 5 p.m. and go at once to the institution, where they have a shower bath and put on regulation clothing; after this they have dinner, followed by a 'quiet hour' during which they may sleep. The doctor's examination is then made, after which, from 7 to 9 p.m. they may take walks, play games, or attend entertainments by visiting artists. Supper follows, and the guests retire to bed at 10 p.m. They rise at 6.30 next morning for physical exercises and breakfast. By 8 a.m. they are at work in the factory, returning to the sanatorium at noon for lunch. The diet includes meat or fish three times a day, with butter, vegetables, etc., and extra vitamins, cod liver oil, and haematogen. Any special treatment which may be required is provided at a local polyclinic at which it is usual to arrange for x-ray examination as soon as the worker is accepted for sanatorium treatment. D. C. N.

Flicker Fusion Frequency as a Test of Fatigue. BROZEK, JOSEF and KEYS, ANCEL (1944). *J. industr. Hyg.*, **26,** 169.

The flicker fusion frequency (F.F.F.) is defined as the frequency, in flickers per second, at which an interrupted light appears as a steady light. The rate at which fusion occurs varies from individual to individual; e.g. in a group of 56 subjects it ranged from 36·5 to 56·0. The fusion level does not change with practice, and it was not affected adversely by one to four hours of hard treadmill work. When the subjects were doing physical work near to the limit of capacity in air at a temperature of 120° F., the F.F.F. decreased slightly from day to day, and it also decreased very slightly when the subjects did 2½ days of very hard work with inadequate food intake. It decreased more noticeably from day to day on a regime of hard work and total food starvation; e.g. from 56·2 to 53·0 in one group of four subjects, and from 55·5 to 54·2 in another group. As the changes observed in the tests were frequently not statistically significant, it is concluded that the F.F.F. cannot be considered a sensitive indicator of 'general fatigue.'
H. M. V.

Silicosis in Miners. From Donetz Institute of Labour Hygiene and Occupational Diseases, U.S.S.R. (1941).

Incidence.—Pneumokoniosis affects 3·3 per cent. of workers in soft coal, and 1·1 per cent. of those in anthracite mines. Examination for tuberculosis showed this disease in 1·6 per cent. of underground workers in soft coal, in 3·5 per cent. of surface workers, and in 2·5 per cent. of workers' wives.

Preventive Measures.—Wet boring, dust extraction, periodic medical examination, extra milk, special clothing, 1 month annual holiday.

Radiological Changes.—Reticulation, going on to

* The first lecture only was abstracted in this Journal, 1944, **2,** 128.

nodulation, then to conglomerate (tumescent) formations, with emphysema. Right lung often more affected than left. Differential diagnosis between silicosis and tuberculosis:—

	Silicosis	Tuberculosis
Nodules	Vary much in size.	All about same size.
Area affected . .	Middle and lower lobes.	Whole lung.
Outline of nodules	Clearly defined.	Ill-defined.

Effects of Temperature.—Changes in lungs occurred more rapidly at higher temperatures.

Mineral Admixtures.—These are not responsible for the formation of anthracotic nodules—which appear more constantly with pure (ash-free) coal-dust than with dust containing much foreign mineral.

Pathogeny of Silicotic Nodule.—(Based on experimental data.) Nodule begins as a cell-accumulation in lung alveolus. Multinuclear cells appear, and fibroblasts are present early (shown by silver staining), appearing before collagen fibres. Formation of these nodules is not connected with tuberculosis—the name of ' pseudotubercle ' (Mavrogordato) is misleading.

Effect of Lymphagogue on X-Ray Appearances.—Administration of Witte's Peptone (dose and route not stated) is followed in a few hours by increased density of reticular markings which disappear in 24 hours. This may assist in diagnosis in an early case in which signs of reticulation are doubtful.

Damping of Coal Dust.—Dust evolved by use of pneumatic drill can be eliminated by damping or extraction. Dust can only with difficulty be damped with water, owing to presence of gases adsorbed on surface of dust particles. Addition of powders such as sulphur, graphite, or talc (non-water-retaining) assists, especially if solutions of lower surface tension than that of water are used—e.g. soap or electrolytes. Damping solutions were tested for surface tension (which should be 73–75 erg./sq. m.) by Traube's stalagmometer, and for acidity (*p*H) which was determined electrolytically and varied from 11 (sodium chloride solution) to 4 (iron sulphate solution). Naphtol soaps and acidol are cheap by-products of petrol extraction, and lower surface tension of water. They are prepared by lixiviation with sodium hydroxide to *p*H 11. When used in a 0·16 per cent. solution naphtol soap gave good results. Hard water is unsuitable as it is liable to form an insoluble precipitate. Water can be softened by addition of sodium hexametaphosphate, or 0·1–0·2 per cent. calcined soda. The softener should be mixed ½–1 hour before introduction of soap. Use of a naphtha soap solution in the Nikitove Mercury Mines showed reduction of dust particles from previous 3816–7355 per c.c. down to 320–671 per c.c. D. C. N.

Dust in Steel Foundries. First Report of a Committee appointed to consider methods of preventing the production or the inhalation of Dust and the possibility of reducing the use of materials containing Free Silica in Steel Foundries (1944). H.M.S.O., Lond. Pp. 23. 6*d*.

The report points out that since the fettling of steel castings was recognized in ' The Various Industries (Silicosis) Scheme ' in 1931, it had been realized that workers in steel foundries were exposed to the risk of silicosis. The number of certified cases of the disease rose from six in 1937 to 26 in 1942. The committee was therefore appointed with the above terms of reference. They report that the main processes common to all foundries include (i) the preparation of the moulding materials; (ii) the making of moulds and cores; (iii) the making and pouring of steel; (iv) the removal of the castings from the moulds and removal of cores; (v) the cleaning and dressing of the castings. While dust is encountered generally in foundries, the following processes are particularly dusty and require special consideration:—(*a*) easing, (*b*) ' knocking out,' (*c*) stripping, (*d*) rumbling, (*e*) blasting, which includes compressed air blasting and wheel abrading, (*f*) the use of pneumatic chisels, (*g*) the use of hand tools, and (*h*) grinding. Medical opinion is that the chief risk to the worker is silicosis and that this disease is caused by the inhalation of very small particles of silica in the free state. The methods of combating the risk are by substituting other materials for free silica, by reducing the amount of dust, and by preventing its inhalation.

The chief constituent of moulds and cores is sand (free silica), but since 1,500,000 tons are used a year it is not possible to recommend any practicable substitute. Specially fine free silica is sometimes used in moulding compositions, parting powders and silica paint, and so the committee recommend that in these substances it should be replaced by suitable non-siliceous substances such as coloured aluminous fire clay (chamotte). The abrasive in general use in steel foundries is steel shot; but as sand is occasionally added this practice should cease. The assistance of the Steel Castings Research Committee has been sought in considering the possibility of substituting materials containing no free silica in the linings of converters and ladles.

In order to reduce dust the committee recommend that effective measures be taken to prevent the escape of dust from blasting apparatus and that efficient ventilating plant should be provided. The plant should be kept in good repair and in continuous use. Workers can be prevented from inhaling dust by the use of suitable protective helmets which should be supplied with warm, pure, filtered air at a rate of not less than 6 cubic feet per minute. Helmets, gauntlets, overalls and other protective devises should be kept clean by vacuum cleaners and there should be suitable storage accommodation provided close to every ' blasting enclosure.' Suitable respirators should be provided for and worn by fettlers and dressers of steel castings. The committee also advise that no person under 18 years of age should be employed on or within 20 feet of any blasting apparatus. The report concludes with three appendices on (*a*) steel foundry moulding materials, (*b*) air supply to protective helmets, and (*c*) dust concentrations in shot blasting chambers in steel foundries. The Grinding of Metals (Miscellaneous Industries) Regulations, 1925, dated September 2, 1925, made by the Secretary of State under Section 79 of the Factory and Workshop Act, 1901 (1 Edw. 7, c. 22), for the Grinding or Glazing of Metals, or Processes incidental to the Grinding of Metals, or the Cleaning of Castings, is also quoted in full. K. M. A. P.

Silico-tuberculosis. AUERBACH, O., and STEMMERMAN, M. G. (1944). *Amer. Rev. Tuberc.*, **49**, 115.

The course of the disease in 54 cases of silico-tuberculosis, 9 cases of pneumokoniosis without tuberculosis, and 200 cases of tuberculosis without pneumokoniosis, was studied and compared. Although silicosis and tuberculosis existed together in the same lung, each maintained its individual integrity. Tuberculosis does not alter the form of silicosis; pneumokoniosis only alters the tuberculosis in so far as the silicotic nodules prevent the full development of tuberculous granulation tissue. The size, situation, and number of cavities are approximately the same, but there is a slightly greater incidence of perforation of cavities through the interlobar fissures in the silicotics and a greater incidence of death from fatal pulmonary haemorrhage. This is due to the greater productive reaction in the silicotic lung with more opportunity to develop an aneurysm of a branch of the pulmonary artery. Collapse therapy was found to be of little value in cases of silico-tuberculosis. This is due to the fact that the silicotic lung remains voluminous and shows no tendency to collapse. Most cases succumbed to progressive pulmonary insufficiency resulting from the invasion of the remaining resilient lung tissue by the tuberculous process. K. M. A. P.

The Treatment of Silicosis by Aluminium Powder. CROMBIE, D. W., BLAISDELL, J. L., and MACPHERSON, G. (1944). *Canad. med. Ass. J.*, **50**, 318.

One hundred and twenty-five employees engaged for 6–23 years in making aluminium powder by a stamping process were examined. They had x-rays taken each year. It was found that aluminium powder did not cause lung damage, nor favour the development of tuberculosis or any other pulmonary condition. Therefore 34 silicotics were treated by the daily inhalation of fine aluminium powder freshly ground from small aluminium pellets in a specially constructed mill. Treatment began with 5 minutes inhalation, gradually increasing to 30 minutes. Some men had received 300 treatments, the majority about 200. Out of the 34 cases studied, 19 showed clinical improvement, apparent chiefly in the lessening or disappearance of shortness of breath, cough, pain in the chest and fatigue. Fifteen cases remained stationary: they were no worse and their condition has not progressed in spite of continuous employment in silica dust during the investigation. Progress of the disease was assessed by means of respiratory function tests repeated at three-monthly intervals. Aluminium dust cannot be regarded as a cure for silicosis since it cannot restore to normal lung tissue which has undergone fibrotic change, but the authors believe that the inhalation of finely particulate aluminium powder offers every prospect of preventing the development of human silicosis. K. M. A. P.

Bagasse Disease of the Lungs. SODEMAN, W. A., and PULLEN, R. L. (1944). *Arch. intern. Med.*, **73**, 365.

This is a record of 11 cases of respiratory disease occurring in men exposed to bagasse dust. A full account is given of the case history of two and a summary of the remaining nine. The length of exposure before symptoms arose varied from 3 weeks to 2 years. Dyspnoea was invariably the presenting symptom. Cough was always present and haemoptysis occurred in four instances. Cyanosis occurred and there was usually some loss of weight. Intermittent fever with temperature ranging from 99·8° to 101·2° F. and persisting for three or four weeks was usual. Impaired resonance and diminished breath sounds with râles chiefly heard at the base were the usual physical signs. X-ray of the chest showed a miliary mottling throughout both lungs, most dense in the hilar areas. Sputum in one case contained a Monilia and in another an unidentified fungus; these were regarded as contaminants. Few of the patients had leucocyte counts of over 10,000. The stay in hospital varied from 9 to 93 days. Skin tests with extracts of bagasse were carried out on 12 patients who had had the disease and 5 controls who had not been exposed to bagasse. They all gave a positive reaction. Lung puncture biopsies during the sixth week of the disease showed pulmonary tissue with several ' spicules ' of an irregular foreign material embedded in it. There was a fibroblastic reaction of the interstitial tissue of the lung. There were many large cells with a foamy cytoplasm in the alveolar spaces. K. M. A. P.

Bagassosis. JAMISON, S. C., BRYAN, M. S., and DAY, J. M. (1944). *New Orleans med. surg. J.*, **96**, 291.

This is a case report of a negro man aged 32 whose work consisted of moving bales of damp sugar-cane grindings from the sugar house to the fields. One month before admission to hospital with severe dyspnoea he was taking the bagasse from the fields to the railway freight cars. This bagasse was dry and was blown about in a fine dust by the wind. Radiograms showed infiltration with a slight miliary appearance throughout both lungs. His sputum was negative for tubercle bacilli on three occasions and no fungi were found. Follow-up examination four months later while the patient was working as a wood cutter showed that the x-ray appearances in the lung had cleared, and the patient was completely recovered. K. M. A. P.

Further Observations on Lung Changes in Electric-Arc Welders. SANDER, O. A. (1944). *J. industr. Hyg.*, **26**, 79.

It is generally recognized that both acute and chronic lung changes may occur when electric-arc welders are exposed to highly concentrated fumes. There is some doubt about the proper evaluation of the chronic changes. In a previous report it was stated that in chest x-rays there might be changes consisting of discrete nodular shadows uniformly distributed throughout both lungs. A recent re-examination of five welders after an interval of some years showed, on the whole, no increase of the pseudo-nodulation. Reports are coming in from all parts of the country describing these nodular shadows, but an examination of 500 welders' films showed the shadows in less than 5 per cent. However, an examination of 84 welders working on auto and jeep frames showed definite small nodular shadows in 54 subjects. All were typical of iron deposition, and it is pointed out that these lung changes are almost invariably mislabelled ' silicosis ' or ' a typical silicosis.' They should be labelled ' siderosis,' or better still, ' siderosis of welding.' When the atmosphere contains silica dust as well as iron, silicotic nodulation and iron pigmentation may develop, and the term ' siderosilicosis ' may be used. In post-mortem examinations the pigmentation due to iron may be identified by means of potassium ferrocyanide, giving the Prussian blue reaction. It is concluded that electric welding does not predispose to tuberculosis or other lung infections, and that the siderosis causes no functional impairment of the lungs. Acute irritation of the throat may occur with the prolonged confined work in dense clouds of fumes, but this appears to be a transitory reaction leaving no residual impairment. Any respiratory involvement may be prevented by proper precautions such as adequate exhaust ventilation. H. M. V.

Occupational Disease of Electric Welders. JONES, T. R., and LOCKHART, J. A. (1944). *Texas State J. Med.*, **39**, 532.

Electric-arc welding produces a considerable amount of smoke composed of ozone, nitrogen oxides, silicon, asbestos and small particles of iron and iron oxide less than 0·5μ in diameter. Welding rods are usually composed of approximately the same alloy as that which is being welded and accordingly the smoke varies in composition. Acute and chronic respiratory disease result from this form of welding. Acute diseases which follow exposure to a dense concentration of the smoke include pulmonary oedema and pneumonia, sometimes complicated by bronchial ulceration. Chronic bronchitis, pulmonary fibrosis with bronchial spasm, emphysema and fibrosis may result from repeated exposure over a long period of time. Night work seems to cause more symptoms than day work. Exposure may cause haemoptysis in persons with arrested pulmonary tuberculosis. Masks and exhaust ventilation give protection to the workers. When symptoms have developed the only effective way to treat them is by change of occupation. K. M. A. P.

Pulmonary Changes following Inhalation of Beryllium Fluoride. BERKOVITCH, M., and ISRAEL, B. (1940). *Kliniskaia Meditsina*, **18**, v, 117. Moscow.

Inhalation of beryllium fluoride is followed typically by an illness beginning with fever which subsides in a few days, followed by a similar period with no symptoms, after which a second phase supervenes, characterised by cough, scanty sputum, dyspnoea, temperature of 102°–103° F., and cyanosis of face and extremities. Râles are heard over the lungs, especially the lower lobes. The blood shows a fall of haemoglobin, leucocytosis, lymphopenia, and a raised sedimentation rate. The illness usually clears up in 10 days to 2 months.

Forty-six cases were studied by clinical and radiological examination, of which 10 were severe; observations were continued on these for three years. Three stages are described by x-ray appearances: (1) Translucency diminished, root shadows enlarged with ill-defined out-

line. Many small ill-defined discrete opacities appear, especially in middle and lower areas, leaving apices and costo-phrenic angles relatively clear: diaphragm movements are impaired. After 5–6 days this picture changes to next phase. (2) Diminished number of focal opacities, which tend to become arranged in groups along main bronchi, seldom coalescing as in bronchopneumonia. Lung translucency increases considerably owing to emphysema, diaphragm movements still impaired. This stage lasts 5 days to 7 weeks and is marked by clinical improvement, mucopurulent sputum, temperature normal or subnormal. (3) Gradual disappearance of focal opacities and resolution of other lung changes. In some cases root shadows remain unduly dense, with some peribronchial fibrosis.

Radiographic changes are not sufficient for diagnosis; they need to be distinguished from miliary tuberculosis and from bronchiolitis following influenza or measles. In these latter cases, foci are distributed more widely, including spices; they are smaller and tend to coalesce, and in tuberculosis do not disappear in a few days or weeks. Beryllium fluoride affects mainly the smaller bronchi, which have no cartilage in their walls. These show desquamation, their walls become infiltrated with leucocytes, and later they become blocked with inflammatory exudate, leading to minute atelectases, with compensatory emphysema. Resolution of the acute catarrhal stage may be followed by fibrosis.

D. C. N.

Toxicity of Beryllium. HYSLOP, F., PALMES, E. D., ALFORD, W. C., MONACO, A. R., FAIRHALL, L. T. (1943). National Institute of Health Bulletin No. 181, U.S. Public Health Service, Washington, D.C.

Beryllium was discovered in 1797. In the last decade it has become important in making an alloy with copper which is ductile and capable of being cold formed into various shapes which after suitable heat become very hard and have an astonishing fatigue resistance. The economic importance of beryllium is thus out of all proportion to the tonnage produced. The principal beryllium ore is beryl (beryllium oxide). A certain amount of literature has accumulated with reference to 'beryllosis' and 'beryllium rickets,' but no particular toxicity for beryllium can be established in animals. It appears that whatever toxicity has been found to occur with the beryllium salts is due to the toxicity of the acid radicle, such as fluoride or oxyfluoride. Hydrolysis of certain of its salts such as the chloride and sulphate have an irritant effect on the skin.

Absorption of beryllium from the alimentary tract is slight, and it is excreted mainly in the faeces. Absorption of beryllium carbonate from the lungs is very slight. No beryllium compounds dissolve appreciably in serum. Little beryllium is stored in the body, but that which is, is found in the liver and bones.

Two methods, one colorimetric and one fluorescent, of analysis for minute amounts of beryllium in animal tissues are described.

A comparison of the relative toxicities of beryllium, magnesium, and zinc, by intraperitoneal injection showed beryllium to be least, and zinc to be most, toxic.

K. M. A. P.

Dinitrophenol Cataract: Production in an Experimental Animal. ROBBINS, B. H. (1944). *J. Pharm. exper. Therap.*, **80**, 264.

Development of cataract following dinitrophenol has been reported in man but this is the first account of it in an experimental animal. The sodium salt of 2:4 dinitrophenol was mixed with the feed in concentrations of 0·05–0·25 per cent. In chicks and ducks on a diet containing 0·25 per cent. a fine grey opacity could be observed in 4–6 hours and by 24 hours this had progressed to very marked opacity extending over most of the anterior portion of the lens visible through the pupil. On microscopic examination of lens sections taken after 5 hours a fine granular and vacuolar change was observed in the anterior portion of the lens fibres. After 24–48 hours on the drug there was great tissue destruction in the posterior portion of the lens. After 6–8 days the lesions which were present in the anterior portion of the lenses began to resolve, but an abnormal pattern of the fibres persisted. Lesions in the posterior part of the lenses gradually changed from a diffuse destructive type to a cyst-like lesion after 8–10 days on the drug and this persisted throughout the experiments. Development of cataract was not affected by adding riboflavin to the diet. 0·25 per cent. mixture of 2:6 dinitrophenol produced no change: but with 0·5 per cent. concentration in the diet two of thirteen chicks developed a very fine grey opacity in the anterior part of the lens which was present only on the second and third day of feeding. 2:4 dinitro, 6 aminophenol when added to the diet in concentration of 1 per cent. produced lesions very similar to those in chicks receiving a diet containing 0·25 per cent. dinitrophenol.

K. M. A. P.

Industrial Manganese Poisoning. FAIRHALL, L. T., and NEAL, P. A. (1943). National Institute of Health Bulletin No. 182. U.S. Public Health Service, Washington, D.C.

Chronic manganese poisoning has been known since 1837 and occurs principally in five processes: (1) Working up of pyrolusite; (2) extraction of manganese ore; (3) sorting of manganese containing ores; (4) loading manganese ores; (5) in processes involving the evolution of metallic manganese fume. Its most important use is in the production of alloys, of which spiegeleisen, ferro-manganese, silico-manganese and silicospiegel, used in certain grades of steel, are the most important.

In 1883 Kobert showed that dogs treated with repeated subcutaneous injection of small doses of manganese citrate developed nausea, vomiting, and jaundice. Most of his animals developed parenchymatous nephritis with partial or complete cirrhosis of the liver. The toxicity of manganese varies according to the salt administered, the divalent manganese ion being three times as toxic as the trivalent ion. The toxicity of manganese preparations has been shown to depend upon the size of the colloidal particle, since many times the lethal dose may be administered without the development of pathological lesions or clinical symptoms when the particle size does not exceed a predetermined value, but if this size is exceeded, toxicity and death occur.

Chronic industrial manganese poisoning results from inhalation of manganese fumes. It has been shown that workers in contact with manganese are particularly liable to develop pneumonia for which the name 'manganese pneumonia' has been coined, but the most important symptoms are those resulting from damage to the central nervous system. Exposure to dusty ores for three months is sufficient to cause symptoms, but 1–3 years is the usual history. Langour and sleepiness precede weakness of the legs. A stolid mask-like facies develops, and the patient speaks with a slow monotonous voice; muscular twitching follows with nocturnal cramps in the calves and stiffness of the legs. There is a fine tremor of hands or gross rhythmical movements of the arms, legs, and trunk which suggest lenticular degeneration. Marked emotional disturbances occur, and there is a typical Parkinsonian gait. The hand-writing may also show micrography. There are no sensory disturbances. The characteristic lesion common to victims of poisoning is destruction of the ganglion cells of the basal ganglia, followed by gross scarring and shrinking. Sometimes the globus pallidus and other parts of the central nervous system are involved.

It appears that many of the symptoms will disappear or regress if the worker is removed from manganese exposure shortly after the onset of symptoms, although there may be some residual disturbances in gait and speech. Well established manganese poisoning is a crippling disease with permanent disability. Liver, electrotherapy, hydrotherapy, potassium iodide, sodium thiosulphate, atropine and scopolamine have all been tried, but there is no evidence that they produce any benefit. The maximum permissible concentration of

manganese has been tentatively placed at 60 milligrams per 10 cubic meters of air.

Prevention of chronic manganese poisoning can be accomplished by effective control measures which prevent the inhalation and ingestion of manganese compounds. Since the disease can be arrested, periodic medical inspection of workers is important so that early symptoms can be detected. K. M. A. P.

Prophylaxis for Phosphorus Workers. BARON, R. (1944). *Brit. dental J.*, **76**, 331.

Prophylaxis may be divided into three main headings: (*a*) organization of the dental clinic and its records, (*b*) selection of the workers, (*c*) routine treatment of the workers. Any patient who has received surgical treatment should be marked unfit: and a patient who has had a jaw lesion should be permanently excluded from phosphorus process work. Adequate records must be kept of these recommendations. The pallid cadaverous type of person appears to be more susceptible to dental and jaw lesions than the robust, fresh-complexioned type. This should be considered in the selection of workers. Further, a worker with a mouth showing any degree of dental sepsis or inflammation must be permanently excluded. Workers accepted medically and dentally should have x-rays taken of both jaws to ensure that any potential source of sepsis is discovered and eliminated. This x-ray examination should be repeated at intervals. It is better to attain a high percentage of conservative work rather than to follow a policy of extraction. Time spent on prophylactic treatment of gums is seldom wasted. A free issue of toothpaste and tooth brushes, the availability of hypochlorite mouth-wash during working hours, and changing of working clothing all contribute to the prophylaxis of this disease. K. M. A. P.

Modern Phosphorus Caries and Necrosis. KENNON, R. and HALLAM, J. W. (1944). *Brit. dental J.*, **76**, 321.

This gives the case histories of eight men who have worked in a phosphorus factory. They showed a mild form of ' phossy jaw ' which was characterized by small carious sequestra in cyst-like ' cavities.' X-rays show a wide gap between the sequestrum and the healthy bone in every case; the sequestrum occurs in an area of decalcification extensive enough to resemble a dental cyst. It is, however, difficult to differentiate phosphorus caries as distinct from osteomyelitis due to dental sepsis. In no case was there any sclerosis. Lowering of the men's resistance by incidental illness or operation often precipitated a smouldering osteitis of the jaw. The appearance of a dull red spot on the mucosa may be the earliest sign, but sinus formation may be spontaneous or follow dental extraction. Treatment consists of opening the sinuses and the removal of such bone as can be detached by a Volkmann's spoon, together with the sequestra. At least six weeks should elapse before further interference. Syringing should not be necessary. Histologically the sequestra show bone necrosis in the central portion of the fragments: no cancellous bone is visible. The central matter is amorphous. There are a few polymorphs and a little organizing granulation tissue at the edge of the tissue. K. M. A. P.

Health Hazards encountered in the Manufacture of Synthetic Rubber. WILSON, R. H. (1944). *J. Amer. med. Ass.*, **124**, 701.

The manufacture of synthetic rubber involves several chemical compounds which are toxic to man, and this paper deals with experiences encountered in manufacture of certain types. Butadrene is a light narcotic poison with no danger after light exposure. Styrene caused irritation of the nose, throat, and lungs. Coughing occurred in some cases, as also did a mild conjunctivitis. Lassitude and fatigue were constant. No chronic symptoms appeared after removal of the men from contact with the substance. The highest concentration to which they were exposed was 500 parts per million. Acrylonitrile contains vinyl chloride and liberates hydrogen cyanide. It causes nausea, vomiting, headache, fatigue and diarrhoea. All complained of nasal irritation; and in several cases a mild jaundice occurred which lasted several days. There was a slight anaemia. Every care must therefore be taken to prevent exposure. This includes a closed type of operation and adequate ventilation, both local and general. K. M. A. P.

Diagnosis of Carbon Disulphide Poisoning. RODENACKER, A. (1942). *Med. Klinik*, **38**, 828.

Carbon disulphide poisoning is rare but its use in industry, particularly in the manufacture of artificial silk, is rapidly increasing. Acute symptoms, including delirium and mental disturbances, occur if the concentration of carbon disulphide in the atmosphere reaches 0·15 to 0·2 mg. per litre of air. Some workers complain of a fear of insanity, others are aggressive and destructive, others sleep walk, and others become irresponsibly talkative. These symptoms are accompanied by marked loss of weight and impotence. Optic neuritis with amblyopia, paresis of the nerves of the leg, particularly peroneal, intestinal colic and pylorospasm also sometimes occur. Prognosis is good, improvement usually occurs rapidly, and after three or four weeks the patient is fit to return to work. The author considers that the symptoms are the result of an alteration of the organic lipoids in the nervous system caused by the fat solvent action of carbon disulphide. K. M. A. P.

Poisoning and the Hazard of Butanone and Acetone. SMITH, A. R., and MAYERS, M. R. (1944). *Industr. Bull.*, **23**, 174.

Two cases of acute intoxication occurred during the process of waterproofing the seams of raincoats for the Army. There was no exhaust ventilation of any kind. The compounds were applied by brushing, each coat receiving three brushings at intervals of two hours. In the first two acetone was the solvent, in the third butanone. Air tests disclosed concentrations of butanone from 398 to 561 p.p.m., and for acetone from 300 to 495 p.p.m. Case 1, a girl aged 18, complained of gastric distress, watering of the eyes, and sleepiness which passed into coma. Her breath smelt of acetone, but there were no abnormal physical signs except for twitching of the face and hyperactive reflexes. She recovered within 24 hours. Case 2, a girl aged 19, had a fainting attack which was followed by a convulsion, after which she regained consciousness. Evidence is also presented that dermatitis will arise from exposure to butanone alone in concentrations ranging from 300 to 600 p.p.m. There is also a serious fire hazard from this combination of solvent. Concentrations of these solvent vapours sufficiently low to protect the health of workers will automatically provide safe concentrations from fire and explosion. K. M. A. P.

Uraemia following Inhalation of Carbon Tetrachloride. GORDON, A. J. (1944). *J. Mt. Sinai Hosp., N.Y.*, **10**, 792.

This is a case report of a woman aged 22 who worked in a factory where costume jewellery was manufactured. White beads were dipped into carbon tetrachloride to clean them. She had vomited for ten days before admission. She was acutely ill and had a skin rash of dark red and purplish-red macules and large haemorrhagic patches. Her blood pressure was 105/60. There was no oedema. The fundi were normal. The urine was alkaline and showed a cloud of albumin. Her blood urea was 170 mg. per cent. She was treated with intravenous glucose in saline and within 14 days the blood urea was reduced to 24 mg. per cent. Vomiting was the striking symptom and probably caused the azotaemia. K. M. A. P.

Pentachlorinated Naphthalenes in Industry. COTTER, L. H. (1944). *J. Amer. med. Ass.*, **125**, 273.

An account is given of 7 cases of poisoning with pentachlorinated naphthalenes, two of which ended in death.

The process consisted of coating naval wire cable with the toxic substance to render it heat-resisting and water-repelling. Symptoms consisted of a papular rash on the face and hands with bronze pigmentation, drowsiness, indigestion and finally toxic jaundice. Liver sections from the fatal cases showed no normal liver parenchyma; some areas showed complete absence of liver cells over partial destruction of these cells. Those remaining had proliferated to firm nodules without the usual lobular architecture. The central portions of the lobules were haemorrhagic. The onset was usually within a few months of starting work, and cleared up rapidly if the patient was removed from contact with the chemical as soon as the gastro-intestinal symptoms developed.

K. M. A. P.

Experimental Trinitrotoluene Poisoning. HIMSWORTH, H. P., and GLYNN, L.E. (1942). *Clin. Sci.*, **4**, 421.

If large doses of T.N.T. are given subcutaneously to rats, they soon pass a bright red pigment in the urine and become limp. A proportion of the animals die within 48 hours. At autopsy they are anaemic and dehydrated, but the liver shows no evidence of fatty infiltration or necrosis. By contrast in chronic poisoning with T.N.T. there is loss of weight, increased appetite, excretion of high concentrations of red T.N.T. derivatives in the urine. loss of hair, changes in the blood and associated tissues (decrease in haemoglobin, the appearance of normoblasts, reticulocytosis and polychromatic erythrocytes in the peripheral blood, an erythroblastic hyperplasia of the bone marrow and siderosis of the spleen) and hepatic lesions which range from fatty infiltration to an acute necrosis of the parenchymal cells. Since 25 per cent. of workers exposed to T.N.T. have symptoms referable to this cause, any factors which influence the susceptibility to T.N.T. poisoning are of importance. White Wister rats were therefore fed on different diets and 0·15 g. of T.N.T. per kilo of rat each day. It was found that typical necrosis of the liver and a profound anaemia developed in rats taking a high fat diet, whilst in animals taking a high carbohydrate or a high protein diet the ill effects are slight or absent. The fat diet influences the animal's metabolism so as to impede its ability to dispose of the T.N.T. within its tissues. The resemblance between the effects of T.N.T. poisoning in the rat and in man is close.

K. M. A. P.

Grease Gun Injuries. BYRNE, J. J. (1944). *J. Amer. med. Ass.*, **125**, 405.

An account of five cases from the literature and one of the author's own experience is given, in which grease from a grease gun has been accidentally injected into the finger. The grease spreads diffusely throughout the tissue of the finger or hand and may even go into the wrist. The injector does not need to pierce the skin: the grease is ejected at such velocity that it can penetrate the finger at a distance of 8 inches. In the acute phase pressure, chemical irritation of the grease, or secondary infection may damage the tissue beyond repair. In the chronic phase the grease may be pushed out or encapsulated in chronic inflammatory tissue, and may even give rise to tumour formation like other oils such as paraffin. Treatment is conservative; surgery should be limited to the removal of sloughing tissue and incision of fluctuant areas when abscesses develop. Early amputation is to be avoided. When subcutaneous oleomata develop they should be removed. Efforts should be made to inform mechanics of the dangers inherent in the careless handling of the grease guns.

K. M. A. P.

Arterial Occlusion in the Hands and Fingers associated with Repeated Occupational Trauma. BARKER, N. W., and HINES, E. A. (1944). *Proc. Mayo Clin.*, **19**, 345.

An account is given of 11 cases of occlusive arterial disease confined to the hands or fingers. All patients were otherwise healthy men engaged in occupations in which their hands were subject to considerable blunt trauma and pressure. Two used pneumatic drills. The average age at the onset of symptoms was 46 years. The syndrome had developed in the hand which was most used in the man's work. Arteriograms of two of the cases are reproduced and show obstruction to the digital arteries in one instance and to the ulnar artery in the second, a pneumatic tool worker. In four cases, two of whom were the pneumatic tool workers, Allen's test was positive. This consists of asking the patient to make a tight fist to compress blood from the skin of the fingers. The physician then occludes the patient's ulnar and radial artery by digital pressure. The patient then opens his hand. Failure of return of blood to the skin of the hand and fingers indicates obstruction to blood flow in the artery which has not been occluded by the digital pressure. None of the patients showed evidence of acrosclerosis, cervical rib, the scalenus syndrome, or occlusive arterial disease elsewhere. The evidence indicates that arterial occlusion in the hands of these patients is the result of chronic occupational arterial trauma.

K. M. A. P.

The Physiological Principles governing the Action of Acetone together with Determination of Toxicity. HAGGARD, HOWARD, W., GREENBERG, LEON A., and TURNER, J. MCCULLOUGH (1944). *J. industr. Hyg.*, **26**, 133.

This paper is a very detailed study of the physico-chemical relations between acetone and the fluids of the living body. Experimental data were obtained from observations on human subjects and on rats, and by means of them it is possible, from the concentration of the acetone in the air, to calculate the amounts and concentrations in which the acetone exerts its action in the body. Without such knowledge for volatile substances, their toxicology, in terms of concentration in the air, is essentially empirical. Many of the data reported in literature purporting to be measures of toxicity are, in effect, not such measures, but are empirical results which are composites of many physical and physiological factors. Primary features in the physico-chemical relations are: (1) the fate of the substance in the body, whether metabolized or not, and if metabolized, its rate of change; (2) distribution between the substance in the air inhaled and the blood in the lungs; (3) distribution of the substance between blood and tissues; (4) elimination of the substance through the kidneys.

The experimental data described are so numerous that it is not possible to summarize them in a brief abstract, but their application to industrial standards may be quoted. The conclusion is drawn that the upper limit of safety for men performing moderate exertion over a period of 8 hours daily is 5·0 mg. of acetone per litre of air, or 2110 parts per million. Under such exposure the concentration of acetone in the blood might reach 330 mg. per litre for a single day's exposure, and increase on daily exposures to 400 mg. With concentrations above the figure mentioned the blood would never be free from acetone during the entire working week, though it would cause no intoxication. Rats maintained for 9 days continuously at a concentration of 1000 mg. per litre of blood showed slight drowsiness but no signs of intoxication.

H. M. V.

PROCEEDINGS OF THE ASSOCIATION OF INDUSTRIAL MEDICAL OFFICERS, 1944

BIRMINGHAM GROUP

The summer meeting of the Association, due this year to be held in Birmingham on May 19th and 20th, was unavoidably cancelled, but a group meeting was held instead, on May 20th, at the Birmingham Accident Hospital when the subject of accident services was discussed. Before the meeting Mr. E. A. Nicoll showed a new British Council film 'Accident Service' at the Tatler News Theatre, where some 250 members and guests attended. At the hospital Mr. W. Gissane described the policy set up by his Board. The hospital would deal with two-thirds, perhaps three-quarters, of the city's accidents. One main problem was the minor injury, fingers in particular, and the control of wound infection. This latter was the subject of a long-term research by Professor A. A. Miles, acting for the Medical Research Council. The accurate treatment and rapid supervision of say 600–1000 cases a day meant a well-planned system, such as he considered was now to be provided. Mr. Gissane showed plans of the new out-patient and reception blocks (opened by the Minister of Health on August 14th, 1944). All new cases would receive immediate treatment in a special department—with examination cubicles; x-ray room, with mobile unit if required; two operating theatres with sterilizing room and changing rooms for the surgeons; plaster theatre; and photographic unit. Serious cases would be admitted to the wards, and this includes admission of the 24–48 hour case; others go home or, perhaps, back to work. Records would be kept by the Hollerith system. Follow-up systems are important. Patients and their friends can use a bright and cheerful waiting hall with bar-canteen. Surgeons have well-equipped examination rooms, off which branch the main x-ray department for the hospital, plaster rooms, patient's lavatories and waiting room. All re-dressings are seen at each attendance by a surgeon. A special plan for this has been devised enabling a quick flow through for inspection; this department is adjoined by three separate dressing stations for clean wounds, dirty wounds and burns—all ambulatory cases. Above this block was a gymnasium, already working, near which would be rooms for other forms of rehabilitation. Finally, the hospital was intimately concerned with economic rehabilitation: the sheltered workshop for injured persons had come to stay—arising out of the Austin experiment—and plans were already on the table to set up communal rehabilitation workshops for Birmingham as a whole. Some 70–80 members of the Association and guests then toured the hospital and later were entertained, with members of the hospital staff, to luncheon by the group. Dr. R. E. Lane thanked the group for its hospitality and said how disappointed members had been that the main meeting had to be cancelled—and in particular the annual dinner at which he understood nearly 100 members were to have attended. One of the main objects of the Association was to maintain social contacts between medical officers. This meeting had done that in no small manner and had given a lead to the setting up once again of pre-war standards.

On Friday, June 16th, Mr. R. A. Lewty spoke on 'Dental Services in Industry.' He did not need to justify the need for dental treatment: it was essentially supplementary to medical service. Dental treatment did not just mean alleviation of toothache; it means rendering mouths hygienic and efficient, and advising the workers how to keep them so. If a firm was not willing, nor economically able, to install a dental clinic arrangements should be made with local practitioners. The difficulty of this was to arrange for the employee to have time off to attend outside clinics. Evening dental sessions were not in the best interests either of patient or employer. Where a clinic is set up at the factory the dentist should be allowed to visit all departments. He should be a member of the works council. His clinic should be central; it should have two surgeries, waiting room, and clerk's office; and, if possible, a dental workroom. Equipment should be of the best; an x-ray outfit is essential. At first too many people should not be examined prior to treatment. He himself had made this mistake. In his view some 50 workers should be given an initial examination and treatment started right away. Then, each day, 5 or 6 new applicants should be examined. Thus work volume could be more readily controlled. The dental health of juveniles was of much importance; industrial dentistry follows on from the school clinic. Here is a valuable medium for education—at the chairside. Mr. Lewty felt that dental examination should be made compulsory for new entrants. The 'new freedom' was not freedom from responsibility. Dentures are frequently broken by accident; they can rapidly be repaired at the factory clinic. In Normandy, mobile dental repairing units had been sent out to deal with this urgent need, thus proving that the number of young men wearing dentures (but otherwise in first-class physical health) is too high. With toxic substances such as lead and phosphorus dental hygiene is highly important. Wholesale extractions frequently mean loss of working time and are of doubtful value. An industrial clinic affords a unique opportunity for collecting information about dental standards in the community. He had not been able to find sufficient time—because of the great demand for his services in a factory with over 10,000 employees—to carry out such investigations, but in the near future he hoped, for example, to gain information as to why so many young people wore dentures. In 1943 his department had completed over 4000 fillings, thus proving that the workers are willing to submit to conservative treatment when it is made easy for them to do so.

GLASGOW GROUP

At a meeting held on January 28th Dr. William Blyth read a paper on 'Neurosis in Industry.' He laid stress on the implications of war-time restrictions such as travel, black-out, feeding and canteens.

On February 23rd a symposium on 'Industrial Crippling' was arranged. Dr. A. G. Mearns described the place of the cripple in industry, and the relationship, in this respect, between hospitals, general practitioner, and the industrial medical officer. Miss Jean Alexander, Secretary of the Scottish Orthopaedic Council, presented the view of the social service worker. There was an urgent need for hospitals and industry to get together. The present isolationist attitude must go. There were three solutions to rehabilitation: individual placing in selected light jobs inside the works; reconditioning workshops, e.g. the Austin Motor Company scheme; and rehabilitation centres, probably residential, for workers in heavy industries. Miss Marjorie Simpson, Tutor in Industrial Nursing, Royal College of Nursing, gave her views on the industrial nurse's contribution.

The nurse can be of great service to her medical officer in pre-employment examinations, and she can watch for the accident-prone worker. She maintains contact with the injured man in hospital, and helps with after-care on his return to work. Adjustment in hours of work was important. Diabetics and workers with gastric disorders require assistance; there is a need for more special diets at canteens. Of much importance is the nurse's responsibility in educating manager and worker in the meaning of rehabilitation.

Dr. A. B. Doig, one of H.M. Medical Inspectors of Factories, read a paper on 'Factory Law in relation to Health' at the meeting held on March 29th. The health provisions of the Factories Act are based on ordinary principles of sound common sense—for example heating, lighting and ventilation. Factory health laws are every bit as important as public health laws. With the tremendous expansion of medical supervision of factories in recent years, especially by busy general practitioners, there was little opportunity for study of legislation—particularly this classical example of Basic English prose! It was to those people particularly that Dr. Doig spoke. A factory means any premises in which persons are employed in manual labour for the making of any article; the altering, repairing, ornamenting, finishing, cleaning or washing, or the breaking up or demolition of any article; or the adapting for sale of any article. The Factories Act also covers shipyards and dry docks, bottle-washing establishments, laundries in factories or institutions (e.g. hospital laundries), cinema studios, building and engineering construction works, and premises where gas is stored in large gasholders. He described present-day medical supervision, the appointment of Factory Inspectors and Examining Surgeons, and their duties and responsibilities.

On April 26th mass miniature radiography in factories was discussed. Dr. Alex Maclean said that there were certain obvious groups which could be selected for this type of survey, for example the group of tuberculous contacts; this, however, is properly the concern of the tuberculosis officer. Certain age groups showed excessive incidence, for example the adolescent and the period about 40. Certain occupations were more prone to produce the disease than others, for example where there is exposure to silica or asbestos dust. Mass radiography can be applied to persons before employment, during employment, and periodically. Examples of incidence have been—1 per cent. of active tuberculosis among 12,000 applicants for employment in factories in England; 2 per cent. among a group of 417 medical students at a London hospital; 0·77 per cent. of active pulmonary tuberculosis in 18,751 examinations in the Royal Navy and, in another survey, of 0·33 per cent. in 166,598 examinations in the same service; 0·49 per cent. and 0·56 per cent. of active pulmonary tuberculosis in 22,000 and over 100,000 examinations respectively in the Australian military forces; and 0·27 per cent. of active tuberculosis in nearly 20,000 R.A.F. personnel. Most mass radiography units in this country will possess fixed premises from which they will work, but the apparatus is transportable and can be set up at a factory. It may be used therefore in large industrial groups. The first approach to the factory must be made some 8 weeks before it is intended to begin radiography. There is already the sympathetic backing of employers and of Trade Unions throughout the country, and they should, by this time, have commended the scheme to their members. Permission to install the unit must be obtained from the management. Reasons for the survey have to be carefully explained, in particular the fact that there will be the minimum of interference with production. The management must agree that all findings will be confidential between the worker and the medical director of the unit unless with the consent of the individual. This means that the works medical officer is not told the results except by permission of the worker. Time lost by the employees should be paid for, and it has to be clearly understood that all examinations are voluntary. It is important to discuss the whole position with joint production councils and shop stewards. They will be told that probably 5 per cent. of examinees will require further x-ray examination on full-size films, 2 per cent. will need medical examinations, and 1 per cent. will be found to have tuberculosis. By this time some four weeks will have elapsed. The rest of the time will mean intensified propaganda by lectures and cinema displays, by posters, by the personal approach by the works doctor, the nurse and the shop steward, and finally through direct appeals by personal notes in the pay envelope. Dr. Stewart Laidlaw said that mass radiography was to detect early cases. Prospects of cure were extremely good. The Government had made special allowances for cases found to be suffering from tuberculosis, and their rehabilitation was a matter of supreme importance. The small film only shows suspicious findings and cannot be diagnostic. Large films were taken in doubtful cases but even these are not final. Further investigations in hospital and dispensaries were necessary for absolute diagnosis.

LEEDS GROUP

At a meeting held on February 26th Mr. R. Broomhead opened a discussion on rehabilitation. The best form of rehabilitation, perhaps, was 'a good walk.' Treatment of fractures consisted of (1) reduction, (2) maintaining fixation until union occurred, and (3) restoration of function. Successful dovetailing of (2) and (3) produced the good fracture clinic. These criteria in treatment applied also to soft tissue injuries. Definition of rehabilitation was difficult: but Mr. Broomhead suggested that 'restoration of function' covered the field. Function was restored by ordinary physiotherapy; by intensive physiotherapy (sometimes called rehabilitation); by occupational therapy; and by vocational training. In this last phase contact should be made with industrial medical officers. Physiotherapy must take place in hospitals as a rule, although more intensive forms might be carried out at special centres, i.e. for the more seriously injured patient. Occupational therapy could be done both in hospital and at special centres. Vocational training was done at residential centres, Ministry of Labour training workshops, and in special workshops provided within industry itself. Injured workers could be divided into several groups —those who recovered without any physiotherapy; those who needed ordinary physiotherapy; those who required either resident or non-resident rehabilitation; and those who needed training. This phase of training, or retraining, might be carried out at a communal centre serving a large group of workers and industries. Patients much preferred to be treated in their own home towns, but long-term cases might have to go to special centres in the country. There should be an extension of the accident section of hospitals rather than specialized accident hospitals themselves. Segregation of finger injuries, under an orthopaedic surgeon with specialized knowledge, was highly desirable. In Leeds, for example, no headway had so far been made in dealing with this problem of fingers and wound infection.

LIVERPOOL GROUP

At a meeting at Liverpool University on May 16th Professor J. A. Ryle of Oxford University gave an address on 'Social Medicine—Experiments and Prospects.' The Vice-Chancellor was in the chair. Professor Ryle suggested that the physician must in future assume leadership on a larger scale in the social field. Such leadership did not necessarily imply political leadership. He put in a plea for considering social medicine as a discipline, just as clinical medicine was a discipline, and reminded his audience that during the past century medicine could be divided into three main disciplinary periods. In the first period the great contribution had come from the physician-pathologists,

including Bright, Addison, Gull, Hodgkin and Wilks. In the second period the chief contribution had come from bacteriologists and others concerned with the discovery of specific agents of disease. The third period (in which we were living at present) was the period of technical developments, and during it diagnosis and treatment had been greatly advanced by radiology, endoscopic methods, biochemistry and chemotherapy. In parallel with these advances preventive medicine had made its great contributions, but had been denied a sufficiently close association with the other disciplines. The four disciplines had in fact concentrated attention either on diseases or organs, or on specific causes or environmental factors; all had in some degree tended to distract attention from the patient as a person. Social medicine was particularly concerned with man in relation to his environment and with the more intimate study of etiological factors other than specific factors and including housing, nutrition, social insecurity and ignorance. Although during the period of the industrial revolution we had witnessed a greatly improved control of the infectious diseases we had simultaneously witnessed a rising incidence of chronic diseases connected with the stresses and strains of modern life; gastric and duodenal ulcer, chronic rheumatism, hypertension and the psychoneuroses were examples, and in none of these could a specific agent be defined. Yet it was scarcely to be denied that they too were in large measure preventable.

Professor Ryle next stressed the importance of vital statistics and social survey methods as main instruments of social medicine and referred to the value in teaching of the Registrar General's decennial analyses. Slides were shown to illustrate the uses of these in class work when discussing the relationship of mortality to social class, occupation and housing. He then explained in some detail the launching of the experiment at Oxford and the form of teaching, which had been introduced by his statistical colleague Dr. W. T. Russell and himself, for students in the clinical period and gave an account of a socio-medical and anthropometric survey of the pre-school child which was to be conducted from the Institute of Social Medicine. He further mentioned the work of the Bureau of Health and Sickness Records, which was supported by the Nuffield Provincial Hospitals Trust and housed in the Institute under his direction. Relations with public bodies were important, particularly with the health authorities of the city and county; these were likely to prove of value in assisting the work of the Institute. In discussing the prospects of teaching and research in social medicine in this country the speaker suggested that other large university cities might well come to establish departments of social medicine and indicated that the work of these departments might very well in time be particularly directed towards local problems. The natural preoccupations of Manchester and Birmingham, for instance, would be industrial medicine. Cardiff might foster an interest in the socio-medical problems of mining areas. Why should not Liverpool direct its attention to the very pressing problems of maritime hygiene? The health and sickness problems of the merchant seaman, at sea and ashore, and the poor hygiene of our ships, gave cause for grave concern. Shipowners, like the great industrialists, should be more familiar with human needs and with the contributions which medicine and hygiene and welfare services could now make to the improvement of living and working conditions and incidentally to efficiency and output.

NOTTINGHAM GROUP

At a meeting on March 16th Mr. S. A. S. Malkin opened a discussion on 'Rehabilitation.' Before the war the word was used mainly to describe the process of retraining which was necessary when a man was severely injured and could not return to his pre-accident work. During the war it had taken on another meaning. It is used to cover the whole process of treating a man who has been injured, beginning with the initial treatment and continuing until he is fit for his ordinary work or has been retrained for new work. In the past, in the treatment of a man with a fracture, there has been concentration on the fracture itself, but now it is realized that if a man is to make a recovery as quickly as possible all secondary factors which might cause delay must be eliminated. Essentials in a hospital rehabilitation service in contra-distinction to retraining (vocational training) are as follows: (1) There should be good initial and continued treatment and the man's confidence gained. (2) Any anxieties or worries that he may have, and which are apt to delay his recovery by reducing his will to get well, should be eliminated by the help of the almoner who can act as an intermediary between him and his company and the compensation authorities, and who can, if necessary, help in dealing with any domestic difficulties that may have arisen. (3) His interest should be kept up by giving him occupational therapy, the facilities of a good library and encouragement in anything which will prevent him from stagnating. (4) Exercises which will keep the part of his body which has not to be immobilized on account of the injury as fit as possible, so that when he is able to get up this will not delay his progress. All these factors are very important and help to reduce the time of disability which any injury may cause. Vocational training is required by some who are so injured that they cannot return to their pre-accident work. A scheme has been prepared which will be sponsored by, but not under the control of, the Harlow Wood Orthopaedic Hospital. It will be managed by an independent committee and will take patients from a large area and train them for suitable work. This scheme has the approval of the Ministry of Labour, which is prepared to send suitable cases to the centre when it is erected. Steps are now being taken to raise the necessary funds for this and it will be started as soon as they are available. This project will combine voluntary enterprise with government support and should be elastic and able to meet individual needs either of men or industries, so that they may be trained for and provided with the employment which they can undertake. Such a scheme should have a dual effect on heavy industries. It will help men to feel that if they are injured they will not be thrown on the scrap-heap and have to exist on compensation for the rest of their lives, but that they will have the chance to start new lives in which they will be self-supporting and independent of compensation.

The annual meeting of the group was held on April 20th, 1944, followed by a discussion on the white paper on a national health service opened by Dr. J. C. Bridge. He said that many would feel a certain amount of disappointment that an industrial medical service was not included in the suggestions of the Government. The proposals for the national health service were apparently restricted to the establishment of a personal health service. It was stated in the white paper that the subject of health involved not only medical services but also the environmental factors which create conditions of health and prepare the ground for it. The proper continuance of the environmental and preventive services in school and industry might well be coupled with the habit of using for these services doctors who were also engaged in the personal health service. It was quite clear, therefore, that services other than those relating to personal health, including industrial health, had not been lost sight of, and the linking up of these with the personal health service was contemplated. It was not claimed in the white paper that the proposals constituted a comprehensive medical service. The Ministry of Labour, however, had compulsory powers to enforce the appointment of industrial medical officers and these powers would probably be continued after the war and appointments made a statutory obligation. Prior to the war, generally speaking, the only doctors supervising industry were the Medical Inspectors

of the Factory Department and the Examining Surgeons. It was possible that part of the medical service in industry would be effected through the Examining Surgeon, but there was no reason why the general practitioner or the medical officer in charge of a health centre should be excluded from taking his share in industrial medical work. On the other hand, so far as the white paper was concerned, there was nothing to prevent the establishment of an industrial health service as distinct from a personal health service, nor was it necessarily to be supposed that such a service would be under the direction of the authority responsible for the administration of the latter.

In the discussion which followed, Dr. Knox asked whether the Examining Surgeon doing industrial work would be paid by the government or by the employer. Dr. H. A. Summers pointed out that the Factory Examining Surgeons were all general practitioners and in many cases had not experience of factory conditions but had to adjudicate for workmen's compensation. He did not like the idea of one whole time industrial medical officer dealing with several firms. He thought that each organization, if it were not large enough to justify a full-time medical officer, should have its own part-time medical officer. Dr. G. E. Collis felt that doctors connected with industry fell into three groups. Firstly the Medical Inspectorate of the Factory Department of the Ministry of Labour who should maintain close contact with their non-medical colleagues such as chemists and engineers. Secondly the full-time medical officer of whom there were two classes, the first connected with large industries without any special hazards, and the second engaged in industries which were not necessarily large units but associated with a special hazard. In both of these groups the medical officer was to be regarded as a specialist. The third group of medical officers in industry and much the largest was that comprising those organizations having no special hazard and not employing unduly large numbers, in which a specialist industrial medical officer was not required, and for which the part-time medical officer was sufficient. He was of the opinion that payment of the industrial medical officer by the employer was entirely satisfactory and that those who felt anxiety over the possibility of a medical service in industry being discontinued for financial reasons had no grounds for their fears. Once a medical service had been established the employer found that it paid him to continue it. Dr. Collis hoped to work from the health centre in future and felt that this had great advantages in that it enabled contact to be maintained with colleagues. The full-time industrial medical officer had the disadvantage of being out of touch with his colleagues. Dr. Collis took a very different view of some of his patients since he had been a part-time medical officer. Dr. T. A. Lloyd Davies said that the relatively few members of the Factory Medical Inspectorate and full-time medical officers might be regarded as the 'specialists' of industrial medicine, and part-time medical officers as the 'general practitioners'; but it was important that there should be one service, and the work of the factory medical officer should be extended to include that of the Examining Surgeon and the narrow restrictions now placed on Examining Surgeons should be removed so that they might be more approximate to factory medical officers. Dr. Whimster thought that the existing office of Examining Surgeon might well be replaced by the part-time medical officer. Apart from the presence of special hazards he considered that the part-time medical officer was fully able to meet the needs of the situation. Dr. N. L. Lloyd was on the whole against the idea of the part-time medical officer. He thought that so far as large towns were concerned, it would be better to divide the work between whole-time men rather than great numbers of part-time medical officers.

Dr. Bridge then put two questions to the meeting. Was it agreed that an industrial medical service was required? If so, should the industrial medical service be considered outside the scheme of a future comprehensive medical service? The first question was answered in the affirmative and the second in the negative, both by a unanimous vote.

The next meeting took the form of a visit to Kirkby Colliery. Members attended in two groups, one on May 24th and the other on May 25th. None of them had ever been underground before and the visit impressed them with the importance of medical supervision in the coal-mining industry. The stringent precautions taken to prevent accidents were such that a marked impression was made, one which was not likely to be forgotten.

The twelfth meeting took place on August 24th, and consisted of a demonstration by Mr. A. H. Walters of treatment methods in use at the Casualty Department of the Royal Albert Dock Hospital, London. Mr. Walters first described the protection of dressings. Sepsis sometimes arose because of constant penetration of oil and grease through dressings. Wounds can be closed by the application of a solid material such as plaster of paris, or by the application of some protective such as Vizad over the dressings during work. Plaster of paris cots can well remain on for several days, provided primary treatment is adequate. Disadvantages are: liability to become bloodstained from the inside, and dirty, wet, or oilstained from the outside. Generally speaking, heavy workers prefer plaster cots, especially for the first week; and lighter workers ordinary dressings protected by Vizad, during working hours.

Three main points in the treatment of finger injuries are: early treatment to avoid sepsis; keep the part protected and dry; a streamlined dressing to permit rhythmic hand and finger function. Chemical methods can combat sepsis. Protection, and keeping a dressing dry, is often difficult. Vizad is an adhesive viscose film 0·003 mm. thick, specially treated for fluid resistance. It can be easily wiped clean and is without bulk or weight. In Mr. Walters' experience over 80 per cent. of accidents to manual workers involve fingers. Injuries include: superficial lacerations requiring first-aid treatment; deeper lacerations with or without crushing, requiring works surgery treatment; crushes without laceration or fracture, and minor slicing with removal of some tissue also requiring treatment at the works surgery; and severe fractures and compound injuries, requiring hospital treatment. First-aid measures include the application of 2 per cent. brilliant green with spirit, and protection at work. Deeper lacerations can be treated with 1 in 1000 proflavine sulphate solution, or thiazamide powder (M. & B. 760). More serious finger injuries can be treated at the works surgery by immediate immersion in tepid 1 in 1000 buffered proflavine sulphate solution for 15 minutes; minimum debridement; examination for tendon injury; removal of foreign bodies; laceration repair by closely placed horsehair or plastic sutures; removal of pain due to bleeding under nail by trephine. Before sending cases of fracture and severe injury to hospital, these simple measures can be carried out. During this time the patient can be treated for shock.

After the meeting Dr. Lloyd Davies showed cases of dermatitis treated by prolonged soaking in 1 in 1000 potassium permanganate solution, followed by 90 per cent. alcohol, the application of lot. calamin. and an open wove gauze dressing applied to the affected part by stitching the edges together over it.

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